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IGNITION, TIMING AND VALVE SETTING.

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IGNITION, TIMING AND VALVE SETTING.

A Comprehensive Illustrated Manual of Self-Instruction for Automobile Owners, Operators, Repairmen, and All Interested in Motoring.

By

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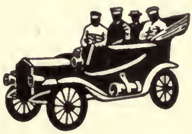

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Preface

Many of the troubles from which motorists have suffered in the past—and still suffer, in fact, despite recent improvements in construction of all the essential parts of the automobile—have arisen from failure of the ignition system to perform its proper function. While these troubles may perhaps be minimized in the latest model cars, there are still in daily use in the United States and Canada many thousands of machines built and equipped in the days of motor-car development, and to every owner and operator, no matter whether his car be new or old, the subject of ignition is of the utmost importance.

To know what to do in case of ignition troubles, it is imperative to learn something definite about the principles of the ignition system used on the car. Intelligent handling of the car in emergencies can only be assured when the operator possesses such information. It will not pay to "go it blind" in seeking the causes of ignition failure. When the engine stops or misbehaves from such causes knowledge is indeed "power."

The object of this treatise is to equip the reader with such a knowledge of the interesting subject of Ignition that he will be able to handle his own particular apparatus with intelligence and skill. The mere consciousness that he understands the principles and construction of his ignition devices will add immensely to his comfort on the road, giving him greater confidence in himself as a driver and stripping the ignition bogey of most of its terrors.

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Then, too, the very practical sections on Timing and Valve Setting will enable the intelligent reader to make all necessary adjustments of his ignition apparatus and should save many a garage bill.

All the systems of ignition in present use are described and illustrated in this work and particular attention is called to the elucidation of the magneto system—both high and low tension methods being described in detail in terms that he who runs (a motor-car) may read. T. H. R.

Contents

PART I.

ELECTRICAL IGNITION FOR MOTOR-CAR ENGINES.

One of the subjects of primary importance to the automobile owner or operator is that of Ignition, or the means employed to produce the combustion of the gasolene "mixture" in the motor cylinder or cylinders. It is altogether desirable, if not essential, that the motorist should acquire a knowledge of this subject very early in his automobiling career and the various methods of ignition employed in modern motor-car practice are here presented in such a manner as to be readily understood, even though the reader has but a smattering of knowledge of the principles of electricity. A careful study of the ignition system used on any particular car is recommended to the owner and operator, and such study will surely be repaid in added comfort of travel and avoidance of ignition troubles.

Whatever may be the system employed on his car, the reader will find in the following pages many valuable hints for his guidance in emergencies. One cannot know too much about the subjects treated.

Ignition—The act of igniting, kindling or setting on fire; also, a means of igniting. A term applied broadly to the apparatus necessary for the ignition of the explosive gases in an internal combustion engine.

Ignition methods may be primarily divided into two sys-

tems—electrical ignition and incandescent ignition. So far as the purpose of the motorist goes, the incandescent ignition may be practically left out of consideration. The type of incandescent or catalytic ignition in which a spongy platinum plug is caused to glow or become incandescent under the influence of compressed gas has been experimented with by many, and in the future may provide some measure of success. At present it would appear that the difficulty of accurately timing the explosion is one which has not been overcome, and, until it is, the system may be put out of court as an efficient method for firing a car engine. We are, consequently, left with practically only one broad principle of ignition, that is by electric spark or sparks; but the multitude of means by which this spark can be produced and regulated makes the question very much wider and more complicated than it would at first sight appear.

Before commencing the study of any of the different systems of ignition it will simplify the matter in the mind of the reader to grasp first the requirements of the internal combustion engine in the matter of the ignition. The cycle of operations inside an engine being understood, it will be seen that the first and most important requirement is that the spark for igniting the charge should take place at a predetermined and easily regulated time relatively to the position of the piston in the cylinder. It being one of the requirements of the internal combustion engine, as made to-day, that the gas charge should be compressed in the cylinder, it is obvious that to get the best results it should also be exploded at the time when it is most fully compressed. This time, of course, is the time when the piston has reached the top of its stroke and is commencing to descend. The greater the delay in the generation of the spark after that point has been reached the less will be the power generated by the explosion, not only because the piston has traveled part of its course, but also because for every fraction of an inch it moves downward the compression of the gas charge is being reduced. It is clear then that as well as the electric spark and the method of producing it, we must have

some method of regulating the time at which it shall take place.

Putting aside the question as to the production of the electric energy required, it will be seen that we not only require apparatus for its production, but we also require mechanical means for the adjustment of the time at which it should operate. This applies to every type of electrical ignition, and no matter what the source of the electric current may be, there must be this mechanical timing apparatus working in conjunction with the engine and capable of being adjusted.

As to the method of its operation we may take an imaginary case of the simplest form of ignition which it would be possible to use. Consider it as consisting of some source of electric energy, such as a dry battery, some means of conducting the electric current to the inside of the cylinder where the explosion is to take place, and some means of causing it there to give an electric spark hot enough to ignite the gas. If our source of electricity were capable of giving us sufficient voltage and current, we might very easily arrange an electrical system which would consist of a couple of insulated wires leading from the source of supply, and, inside the cylinder, some method of causing the ends of these wires to come in contact and allow the electric current to flow, and then, at the time the ignition should take place, to separate themselves by some mechanical movement operated by the engine itself. It is an electrical phenomenon that when an insulated path conducting a current is suddenly broken a spark will pass between the interrupted ends.

While a system operated on these simple lines really covers the whole ground, yet the actual difficulties to be overcome in applying it to an internal combustion engine, as well as the fact that in its simplest form it would be wasteful, render the adoption of more complicated methods necessary. In the first place, the arrangement of a mechanical contact breaker inside the engine introduces difficulties not easily overcome. In the second place, the nature of the current given out by a dry battery is not the most suitable for this particular work. These

difficulties have resulted in the adoption of numerous systems, underlying all of which, however, this fundamental principle will be found. We can divide the systems roughly into two classes, depending on the method of producing the electric energy.

In one case the electric energy is produced by the chemical action taking place between two dissimilar metals or compounds under the influence of an acid or salt; in the other it is obtained from a mechanical appliance provided with permanent magnets, the magnetism of which can be used, under suitable conditions, to produce or induce a flow of electric current; that is to say, the magnetism of the permanent magnets can be turned into electric energy.

The first method uses a dry battery or an accumulator, both being chemical appliances—the first a prime source of electric energy, and the second a storage appliance for electricity produced by any of the known methods and commonly called a storage battery. In the second division the source of power is a magnetic dynamo, usually known as a magneto, and this is driven by the engine. The source of electric energy is thus made part and parcel of the mechanical plant of the car, and independent of any outside source of supply.

The electric system of ignition by magneto is again subdivided into two classes depending on the nature of the current which the machine gives out, about which we shall have something to say further on, but they may be classified here as Low Tension and High Tension. These three sources of current supply—that is, the dry battery or storage battery, the high tension magneto and the low tension magneto—practically cover the entire field, but their application is varied indefinitely, and combinations of any two, or even three, systems are sometimes to be found in one motor.

Battery and Coil Ignition.

We will deal with the system using a dry or a storage battery first. This system is almost invariably of the high tension type, so called because the current of electricity which

is used to produce the spark is of high tension, that is to say, it has great power to overcome resistance to its flow, and this is of the utmost importance in any system of electric ignition, since it is the power of the current to jump across the gap which is made inside the cylinder that causes a spark to pass, and it is on the heat of this spark that its efficiency for igniting the gas charge depends.

The source of energy, which may be either dry battery or storage battery, gives off a current which is of the low tension description. That is to say, while there is a good volume of current, it flows with insufficient pressure to overcome any great resistance to its path. It might be described as a great volume of water flowing slowly through a large pipe. Such a flow of water, supposing the pipe were cut, would not induce any very great jet of water. Imagine, however, the same volume of water passing through a smaller pipe in the same time; it would be forced through with augmented pressure, and, if the pipe were cut, the water would squirt out with great force and cover a considerable distance in the air before falling. While this analogy between the flow of water and that of electricity helps us to get the simplest idea of the simplest electrical appliances, yet it is an unsuitable one to carry too far, because there are other ways in which the current of electricity does not act at all like a current or flow of water. For our immediate purpose, however, this difference between the flow of water slowly in a large pipe, and that of a very rapid stream and a fine jet may be taken to represent the difference between the low and high tension electric current. The pressure at which the current is forced through the conductor —a wire—determines its power to overcome the resistance of the gap across which it has to jump in forming the spark.

We have seen that the current given off by a battery or accumulator is of the low tension variety, that is to say, that it has plenty of volume but little pressure. The quantity per second of electricity we measure in terms of amperes; the pressure we measure in terms of volts, and we therefore call a high tension current a current of high voltage—the voltage repre-

senting the measure of the pressure of the current, and the amperage representing the measure of the quantity flowing per second. We can convert a current of large amperage and low voltage, such as is obtained from a dry battery or accumulator, into one of high voltage and small amperage, such as is required to produce a spark. This transformation in the nature of the electrical current is brought about by the use of a transformer, commonly known as the induction coil. It is the object of this appliance to alter the nature of the current and transform it from one of low voltage to one of high voltage, such as we require.

The operation of an induction coil or transformer relies on an electrical law which may be stated in a simple way as follows: If a current of electricity is allowed to flow in an insulated conductor, such as an insulated wire in a coil, around a soft iron core, its effect will be to cause the soft iron core to become magnetized, that is to say, it will become a temporary magnet during the whole of the time the current is flowing around the core. To make this plain, we would refer to Fig. 1, in which A B is a bundle of soft iron wires and around it is

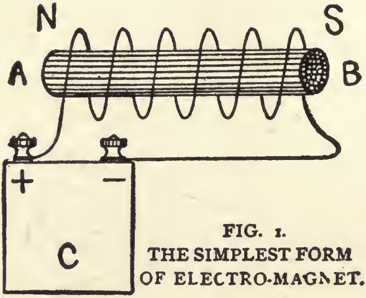


FIG. 1.
THE SIMPLEST FORM
OF ELECTRO-MAGNET.

wound an insulated copper wire—a good many more turns of this being given than are shown in our diagram. C is a dry battery or accumulator from which the current is taken, and from its positive (+) terminal the wire is conveyed round the coil and back to the negative (—) terminal. The result of this arrangement will be that during the time the current flows the soft iron core will become magnetized, having its north pole

at one end and its south pole at the other. The polarity of the magnet is determined by the direction of the winding, and the north and south poles are marked in our diagram.

Upon this winding of wire conveying the low voltage current, which is called the primary, is arranged another winding of very fine insulated copper wire with a great many turns, called the secondary. If the circuit of the primary or low voltage current is broken, there is induced in the secondary winding a current of very high voltage, and it can be shown that the ratio of the primary and secondary voltages is in the ratio of the turns of wire in each. Thus, if the primary was 100 turns and the battery gives 4 volts, with a secondary winding of

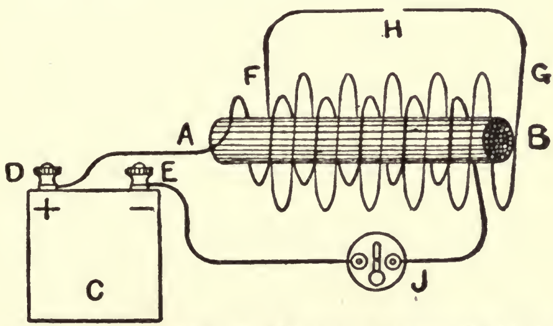


FIG. 2.—SHOWING THE LOW AND HIGH TENSION CIRCUITS OF AN INDUCTION COIL.

100,000 turns we could, theoretically, obtain 4,000 volts. We do not however, obtain so much as this on account of the resistance of the windings and magnetic leakage, but the elementary theory of a transformer is that the voltages are in the ratio of the number of turns in the windings. On again making the circuit in the primary we again obtain a high voltage current in the secondary, and it is this making and breaking of the current in the primary that causes currents in the secondary. This, then, gives us the high tension current which we require for the purpose of passing across the break in the circuit inside the cylinder and causing a spark.

In Fig. 2 we show these two windings together, the thick line representing the primary low voltage winding, and the

fine line representing the secondary or high voltage winding. The primary winding starts from the positive (+) terminal D of the dry or the storage battery, and flows round through the primary winding of the coil to the negative (—) terminal E of the battery. When started or stopped this induces a secondary current, which flows round the secondary winding of the coil through G and F. G and F do not represent any real part or accessory of the actual coil, but are inserted to show the metallic circuit for the current inside the coil. In actual practice they would represent two terminals on the coil from which insulated wires would run to the sparking plug and some part of the engine or vehicle frame respectively, thus completing the circuit.

Supposing, now, we cut out of this secondary winding at H a small piece, as shown, so that there is a distance of about 0.5 mm. or 1-50 inch, between the ends of the wire, and we put in the primary circuit at J a switch, by means of which we can close the primary circuit or open it, we shall find that every time we open the primary circuit (that is, break the metallic continuity of it by means of the switch so that the current cannot pass), we shall get a spark across the two points at H, due to the fact that the pressure, or voltage, of the current is sufficient to make it jump across at H, and the same again when we close the switch.

It would be understood that the current has a certain amount of what may be termed momentum, so that when an obstacle is opposed to its path, such as the air gap which we make when we break the metallic continuity of the circuit, the momentum of the current will tend to break through the obstacle. It is obvious that the more suddenly the obstacle to the flow of the current is interposed, the more effect the momentum will have in overcoming it. It is the momentum which carries the current across the gap and causes the spark. It can also be shown that, on account of this momentum or what is more properly called self-induction of the circuit, the spark, when the current is interrupted or broken, is greater than when it is made by the switch. This effect of the mo-

mentum of the current is also taken advantage of in the condenser, an electrical appliance used in induction coils to increase the sparking effect of the current. Its application and place in the system, a consideration of which at this stage of our investigation would only confuse the reader, is dealt with later.

Supposing this broken part H were on the secondary circuit inside the cylinder, and some arrangement were provided by which the engine would open and close the switch J in the primary circuit, a spark would pass across right in the midst of the gas charge, with the result that the gas in the cylinder would be ignited. This is exactly what is eventually done, but the mechanism required is, for several reasons, somewhat more complicated than that which we have shown.

Let us take first means for breaking the circuit in the primary winding. With an engine working on the four-cycle prin-

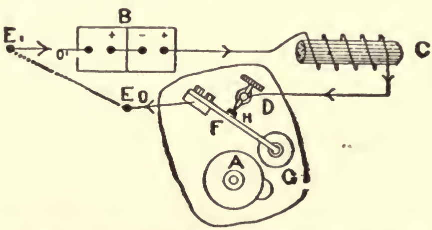


FIG. 3.—THE METHOD OF MECHANICALLY MAKING AND BREAKING THE ELECTRIC CIRCUIT.

ciple it is necessary to ignite the gas charge once for every two revolutions of the engine, that is to say, every alternate time that the piston reaches the top of the cylinder. The appliance by means of which this is done is known as a contact breaker. Fig. 3 illustrates the simplest form of contact breaker. Here is it shown coupled with the primary winding of an induction coil, shown at C, and with a battery, or accumulator, shown at B. A is a shaft which is driven by suitable gear from the crankshaft of the engine, so that it revolves at half the speed of the engine. It is generally the shaft which operates one or more of the valves. On it is a small projection known as a cam. F is a flexible spring blade, having at its

end a roller G. The cam on A, as it revolves, comes in contact once every revolution with the roller G, the result being that the spring blade F is lifted. At H it is provided with a platinum contact piece, which, when the cam lifts the blade F high enough, makes contact with the end of the screw D, which has also a platinum point. As soon as the cam has passed the roller G, the spring blade will return to its normal position, and contact between F and D will be again suddenly broken.

Now D is connected by an insulated wire to one end of the primary winding of the coil C, the other end of which is connected to the positive (+) terminal of the battery B. D is insulated from metallic contact with any part of the engine by means of a suitable insulation, but the spring blade F is fixed by metallic screws to a plate which is in metallic contact with the engine. The negative (—) terminal O1 (Fig. 3) of the battery is also connected by an insulated wire with some part of the framework of the engine or car, it being one of the laws governing the behavior of electric current that it will flow back through what is termed "earth" or "ground" to the source of supply. It is, therefore, unnecessary to lead the current back by an insulated conductor so long as whatever it is coupled to has metallic connection right through to the other terminal of the battery or accumulator.

Suppose, then, we imagine the current starting out from the positive (+) terminal of the battery B, traversing the coil C, passing through the screw D to the contact piece at H (while they are in contact with each other), and so through the engine and frame of the car back, by means of the terminal E (which is connected to the frame somewhere), to the negative (—) terminal of the battery. It will be seen that this current can only flow when the cam A has lifted the blade F into contact with the screw D, there then being a complete metallic circuit for the current. The moment the blade F is released, when the cam has passed the roller, the circuit is broken and the current ceases to flow. It is only during the time that the current is flowing that the soft iron core C becomes a magnet,

its magnetism ceasing almost instantaneously as soon as the contact is broken at H. In actual practice this contact breaker is arranged so that, within certain narrow limits, the time at which the cam on A will leave the roller G can be adjusted. This is done by allowing the whole of the mechanism, including the blade F, the contact screw D, and the roller G, to be oscillated round the shaft A. This completes the low tension circuit.

In Fig. 4 both circuits, the primary or low tension and the secondary or high tension, are shown. If the diagram is examined it will be seen that the low tension wire is exactly the same as in Fig. 3, but is here shown with double lines.

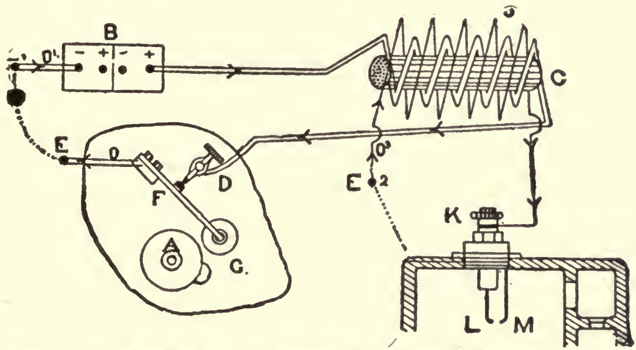


FIG. 4.—DIAGRAM OF A COMPLETE ELECTRICAL IGNITION SYSTEM.

The secondary winding will be seen indicated by fine single lines surrounding the low tension winding on the core C. E is some point at which the insulated wire, forming the secondary circuit, is metallically attached to the frame, or, as it is technically termed, "grounded." As soon as the contact maker makes contact the current flows round the primary circuit, as before described, and when contact is broken induces in the secondary circuit a high tension current. This flows from the coil C to an insulated plug in the cylinder.

This plug is formed with a central porcelain barrel or cylinder, down the inside of which runs a wire L, the end of this being of course, inside the cylinder. Another wire M, term-

inating in a point, is metallically attached to the body of the plug, which, being screwed into the cylinder head, is in metallic connection with it. The high tension current will thus flow down the insulated wire L, and to get back to the coil again through the engine and frame of the car it must jump across between L and M. It thus causes a spark across between these two points the moment contact is broken by the contact breaker at F, the result being the explosion of the charge inside the cylinder. The plug shown at K is known as the spark plug, and in all systems of ignition, except the low tension magneto system, a spark plug of this description becomes necessary.

This air gap between M and L is an important feature of the appliance. Air is a non-conductor—that is to say, a current of electricity cannot pass through air unless it has a high tension or voltage, nor can it pass through any very great body of air. Moreover, if the air be compressed, the difficulty of getting the current to pass through it is considerably increased. It is necessary, then, to so arrange the points M and L that the distance between them is not so wide as to cause too great a resistance to the passage of the high tension current through the air between them; the closer they are together, the easier it is for the current to jump across. On the other hand, if they are placed too close together, the current will pass so easily across that only a modified spark will take place, and it may be that this spark will not be of sufficient heat to ignite the gas charge. In usual practice, with the voltage of current generally used for motor engine ignition, the distance between these two points may be fixed at about 0.5 millimeter, or 1-50 inch. When magneto ignition is used, as will be described later, it has been found that the distance of the points of the sparking plug from each other requires to be less to give the best results, and one of the best known firms of manufacturers of these appliances recommends a distance of 0.4 millimeter. The resistance set up by compressed air to the passage of the current has to be remembered in adjusting sparking plugs, because a spark which would be suffi-

cient to ignite the charge at atmospheric pressure might be found so attenuated when taking place inside the cylinder, with the high pressure often reached there, as to be incapable of firing the gas charge.

The system of ignition which we have just described is applicable to any internal combustion engine either of one or more cylinders, or of the two or four cycle type. In the case of the two cycle type, the make-and-break will take place at every revolution of the engine shaft, because in this type of engine there is an explosion on every down stroke of the piston. Where engines with multiple cylinders are concerned, the method of arranging the ignition varies considerably, and we may subdivide these methods as follows:

(1) Where there is a separate induction coil to each cylinder.

(2) Where there is a single coil for all cylinders.

In the first method it will be necessary to have a contact breaker or maker which will act as a distributer—that is to say, it will have to be so arranged that the low tension current from the battery or accumulator is sent alternately to each of the coils.

In the second method, one contact maker will send the current to the single coil every time a cylinder is to be fired. In the case of a four-cylinder engine this would mean twice for every revolution, and the high tension current in the single coil would be generated each time a cylinder was to be fired. In this case it becomes necessary to have some arrangement to distribute the high tension current to the cylinders in rotation, and this means that in addition to the contact breaker driven by the engine, there will have to be a mechanical appliance, also driven by the engine, to distribute the high tension current. The arrangement of the wiring for these two different methods will be dealt with later, but we may say that the latter method of dealing with the high tension current is known as synchronizing the ignition, because, there being one coil, the interval of time between the flow of the low tension current and the induction of the high tension current will, in

all cases, be the same for all cylinders; whereas when a separate coil is used for each cylinder, variation in the conductivity and the inductivity of the coils may arise, and cause differences in the timing of the different cylinders, which would affect the running of the engine to a considerable extent.

There is another appliance used which as yet we have not mentioned. This is the trembler. The trembler is, in most cases, part of the coil, and one of its functions is to make and break the circuit in the primary winding of the coil rapidly and frequently. In the diagrams which have been drawn there

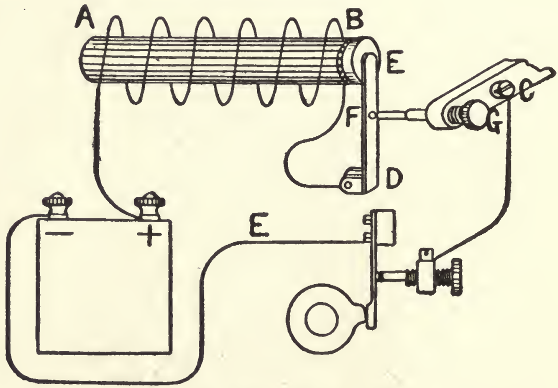


FIG. 5.—THE TREMBLER ON THE COIL

would obviously be only one break of the low tension circuit, and correspondingly there would be only one wave of current in the high tension circuit. There would also be disadvantages, which have been overcome by using the trembler as the appliance whose function it is to break contact—leaving the mechanically driven appliance on the engine to make contact.

The object of the trembler is, by electrical means, to make and break the circuit rapidly so as to insure more than one spark across the sparking plug, because at every break a spark will pass in the high tension circuit.

In Fig. 5 is shown the action of the trembler, and in this diagram only the low tension winding is included, it being

understood that the high tension winding is around this, and that the high tension circuit will be broken just the same as the low tension, owing to the inductive effect ceasing when the break takes place in the primary circuit by means of the trembler. AB is the soft iron core, and opposite to it is arranged a spring blade F, firmly fixed to the coil case at D. At its outward or free end it is provided with a circular soft iron armature E, which normally lies just opposite the end of the soft iron core AB, but a very small distance from it. On the blade F is a circular platinum point, which comes opposite a platinum point at the end of a screw G. This screw G is in circuit with the low tension winding, and as soon as the engine makes contact at the contact maker (as it is called in this case), the current flows from the battery positive (+) terminal around the coil to the plate at D, through the plate and across the contact point F, through the screw G, through the contact maker on the engine, and to ground, which is indicated by the line marked E.

Immediately this takes place, however, the soft iron core AB becomes magnetized and draws the soft iron armature E towards it, the spring blade F allowing of this. It will be seen, however, that the moment this blade is deflected toward the core, the contact will be broken across the point F and the screw G; the current will then, of course, cease to flow through the coil, the core will immediately become demagnetized and the spring blade F will resume its normal position, being no longer attracted by the core. In doing this it will again make contact, the current will again flow, the core will be again magnetized, the armature E will be again drawn toward it, and contact will be again broken. This cycle of operations will continue at a very rapid speed, the speed depending to a large extent upon the nature of the spring F. This is exactly the same arrangement as in an electric belt, where the hammer is connected to a spring so attracted to and released by an electro magnet.

As a result of the action of the trembler, there will be a very rapid making and breaking of the low tension current,

and therefore a very rapid series of currents induced in the high tension circuit, so that at the sparking plug there will be a series of sparks. Opinion is not unanimous as to the real utility of the trembler, but it is almost universally used.

It is a great advantage that the break takes place very rapidly, for the more rapid the break the greater the power of the current to jump the gap. In the case where no trembler is used on the coil, but where the engine breaks contact, as in Figs. 3 and 4, the speed at which contact is broken is determined by the speed of the engine, because the rapidity with which the cam on the shaft A leaves the roller G determines the sharpness with which the contact points at F will separate from each other. It will be seen, therefore, that with the method where a trembler is used we can do away with the necessity of a quick break of the contact, and the mechanism on the engine has for its function the making of contact, rather than that of breaking it, the latter function being left to the trembler on the coil. The engine appliance, therefore, becomes a contact "maker," and can be arranged in a different manner from the contact breaker, it only being necessary to provide for the closing of the circuit, the speed at which it is closed being, within certain limits, immaterial.

Where more than one coil is used, one trembler can be utilized for all the coils, it being put into circuit with the low tension winding, and having a separate electromagnet or coil of its own to operate it as a trembler. In this way a trembler need not necessarily be part of the coil; it may be inserted anywhere in the primary circuit. When such a trembler is used separately, it of course must have a coil and soft iron core of its own, the convenience of having it in the coil being that the magnetism of the core of the coil and the primary winding may be used to operate the trembler, thus doing away with a multiplication of parts.

We have now dealt in diagrammatic form with the principles which underlie the different arrangement of the appliances for a high tension ignition system. It will, therefore, be advisable to describe the different ways in which the var-

ious appliances may be coupled together for different types of engines. The wiring up of such an ignition system often seems to be complicated, but if we start from a simple system, and describe the principle on which the electrical circuits must be arranged in all cases, no difficulty will be experienced in following even the most intricate arrangement. In the first place, it must be borne in mind that no current can pass from any source of electrical energy unless it has some metallic conductor—that is to say, from the positive (+) terminal of the battery or accumulator or any other source of electrical energy there must be a metallic connection right through to the negative (—) terminal. Whenever this metallic connection is broken or interrupted, no current can flow. This, of course, is true practically of any current of electricity, with this great exception, that if the current is of sufficient voltage it may be made to jump across an air gap.

This conductor or metallic path for the current must be insulated from other metallic parts in order to lead the current, as it were, to the place where we want it to do work. Having led the current by these insulated paths through all the appliances necessary for the working of the ignition, it is not necessary that we should provide an insulated path for it to get back to the battery or accumulator. As a matter of fact, it is, strictly speaking, incorrect to say that the current flows in either direction; but for purposes of making it clearer, and for this purpose only, we may consider it as flowing from the positive (+) terminal of the battery to the negative (—), although it is really immaterial in which order we couple the battery up to the different mechanisms which are incorporated in the system. We can regard it that the current, having been led to the place where the work is to be performed, will find its way back through the mechanism of the car or engine if we lead it to the latter by an insulated wire. This we call "grounding" the current, and the points at which we attach the insulated wire to the car are termed "grounds." It is obvious that to lead the current back in this way the battery must also be connected to some metallic part of the frame.

Another point to remember is that it is not very material in what relative order in the circuit the different appliances shall be coupled or inserted. Thus we might lead a wire from the battery straight to the contact maker on the engine, through that to the coil, and from the coil to ground; or we might lead the wire direct from the battery to the coil, out through the coil to the contact breaker, and from the contact breaker to ground; the place at which the contact is broken in the circuit, whether it comes before or after the coil, being quite immaterial. Convenience in the design of the mechanism itself generally results in the contact breaker being the last mechanism in the circuit, because then only one part of it need be insulated, the current flowing through the mechanism itself and the engine, back to the battery or accumulator. It will be seen that this is purely a question of convenience, and is not an arbitrary arrangement of the different connections.

This necessity for a metallic circuit for the flowing of the current applies both to the low tension and the high tension circuits, and the grounding of the current applies to both. It must be understood, too, that both for the low tension and the high tension currents there must be complete metallic circuits, separate and distinct from each other. It greatly simplifies the comprehension of the system if we remember that these two are separate and distinct currents, that it is not the low tension current in another form which is sent out by the coil, but that the coil may be considered as actually being the source of the high tension current. This necessity for a complete circuit for either high or low tension current applies to every form of ignition, whatever the source of the electrical energy; thus it applies to both the high and low tension magneto systems, which we shall describe later.

We may now take a simple form of wiring where there is one cylinder. It may be well here, for the convenience of motorists who may use these descriptions to help them in wiring up their electric ignition systems, to point out that on different coils different internal windings are arranged, and sometimes one terminal can be used for two purposes, the

coupling up inside the coil being arranged to allow for this. The figures or letters on the different terminals of the coils designating their purpose also vary, according to whether the coil is of American, British, French or other manufacture, and also with different makers. The coil, of course, has to carry both the high and low tension circuits through it; therefore there must be provided terminals for these two circuits. The following letters and their meanings in English and French will enable most users to wire up the ignition system correctly. The terminal which connects the coil to the battery may be marked P, B or A. P represents in French "pile," or battery, and is used by French makers indiscriminately to refer either to an accumulator or any kind of primary battery. B on an American or British coil will mean battery, and A will mean accumulator, but it must not be confounded with B on a French coil, which usually stands for "bougie," the French name for the sparking plug. The terminal on the coil for the connection with the contact breaker or contact maker will be marked on a French coil with T, standing for "trembleur," the French term used for a contact maker or a contact breaker. On an American or British coil this will often be marked C. The wire which conveys the current to ground will be attached to the terminal marked on a French coil M, which stands for "masse" (frame), the equivalent of our electrical term "ground." The terminal carrying high tension current to the sparking plug, as we have seen, will be marked B for "bougie" on a French coil, while on an American or English coil it will sometimes be marked S, sometimes P, and sometimes SP.

It will be seen that the two letters P and B, according to whether they are used on American or other coils, stand for different appliances; thus: B on an American coil is battery, and B on a French coil is "bougie," or sparking plug. P on an American or English coil may mean plug, while on a French coil it will mean "pile" or battery. The fact that no American coil will be marked with the letter M at any of its terminals, and that practically no French coil will be without this letter on some terminal affords some guide as to

whether the coil is of American, English or French manufacture, and will enable the user to determine what the different terminals are for.

Let us now take the wiring of a simple electric circuit, such as that used on the single-cylinder De Dion car (Fig. 6). This is a system in which the contact maker acts as the trembler in the same way that we have explained in the earlier part of our description of the ignition methods. Here we have the battery, or accumulator, and from the positive terminal of this a wire runs to the terminal P on the coil. This terminal P conducts the current through the primary winding of the coil, after which it leaves the coil at the terminal A, and from there

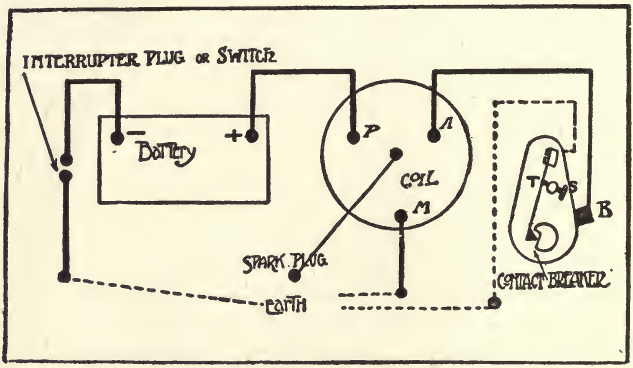


FIG. 6.—THE CIRCUIT OF A SINGLE-CYLINDER ENGINE.

is led to the contact breaker on the engine. From the contact breaker it passes across the contact breaker points to earth (ground) in the engine and so back to the battery, the negative (—) terminal of which is connected to earth. In our diagram the insulated wire connecting the negative (—) terminal of the battery to earth, or the frame of the motor, is intercepted by a switch or plug.

This is very convenient for putting the ignition system out of action, so that under no circumstances can the current flow, even if the engine is rotated to make contact at the contact breaker or maker. It is well to say here that this switch or interrupter can be put in any part of the circuit of the primary

current, and at whatever part it is put in it will completely prevent the current flowing through the circuit. In this diagram the secondary winding of the coil is represented by the central terminal, from which a wire runs to the sparking plug. This secondary circuit is grounded through the terminal M, from which a wire is led to any part of the engine or chassis frame. The other end of the high tension circuit is grounded through the sparking plug by means of that part of the sparking plug which is screwed into the cylinder. This is the simplest form of wiring for any kind of electrical ignition on the high tension system and using a dry battery or accumulator and a coil.

In the case where two cylinders have to be fired and where two coils are used, the contact maker or breaker must act as

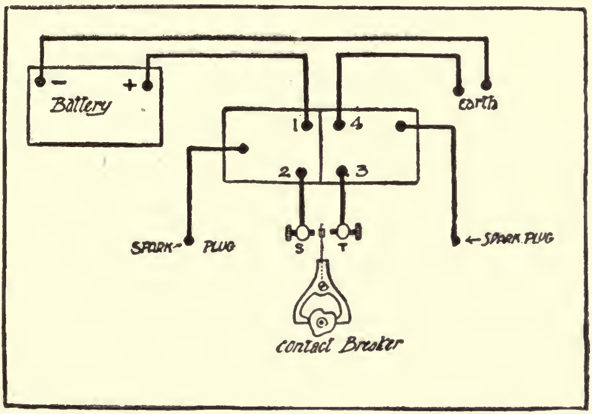


FIG. 7—A SIMPLE IGNITION CIRCUIT FOR TWO CYLINDERS.

a distributer and distribute the low tension current alternately to one or other of the two coils. In Fig. 7 we have the battery, from the positive (+) terminal of which the current is conducted to the low tension wiring of the coil on the left-hand side. Having traversed the low tension winding of the coil, the current is taken from terminal marked 2 to one of the contact screws of the double contact maker or breaker. When this makes contact with the platinum contact screw, which is marked S, the current flows through the contact breaker to

earth through the engine and back through the negative (—) terminal of the battery, which is grounded as shown. The high tension current is then induced in the secondary winding of the coil and flows out of the terminal of the coil to the spark plug. Exactly the same thing takes place when the contact maker or breaker makes contact with the screw T on the right-hand coil. This causes the current from the battery to flow through the primary or low tension winding to the right-hand coil, and out at the terminal 3 through the contact breaker and grounded terminal to the battery. It induces a high tension current in the outer winding of the coil, and this flows through to the sparking plug in the second cylinder, and from that is grounded through the engine. The high tension current induced in both coils is grounded through one terminal common to both, and marked 4. By this arrangement the contact breaker alternately makes and breaks the circuit of the low tension current in either coil, and it is at the time of breaking contact that the spark passes across the points of the sparking plug.

If instead of using the De Dion contact breaker the cam which operates it were so arranged as to make contact for some appreciable length of time, and each coil were provided on its low tension circuit with a trembler, this diagram would represent the arrangement adopted where two trembler coils and one contact maker are used, as is the case in the majority of two-cylinder cars. The features in which the De Dion system differs from others are as follows: It uses a contact breaker instead of a contact maker, and this appliance, driven by the engine, takes the place of the trembler used in other systems, where the engine-operated appliance is used, not to break contact, but to make contact, as we have described earlier.

Supposing now that we wish to use a single coil with a two-cylinder engine, we should have to arrange it as shown in Fig. 8. In this case the wire conveying the low tension current runs from the battery direct to the primary winding of the coil at A. Having left the primary winding of the coil at

the terminal B it flows to the contact maker, and this is arranged so that the wiper C will make contact at two places, D and E, at each revolution; that is to say, it will ground the low tension circuit once in every revolution of the engine. Hence it is apparent that a high tension current will be induced in the coil once in every revolution of the engine and the coil, having a trembler, as described, on the low tension circuit, the secondary or high tension current will be violently and rapidly broken once in every revolution. It is necessary

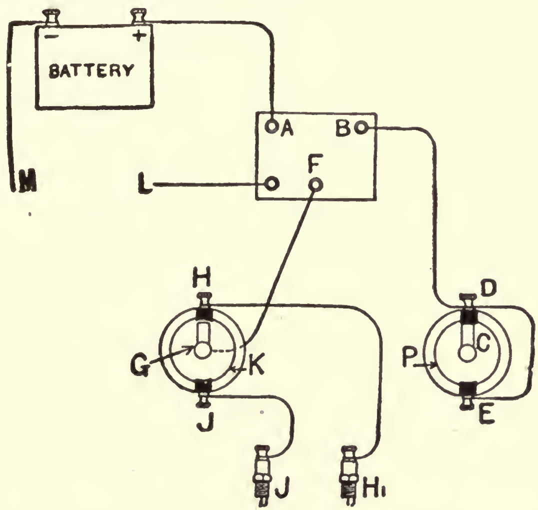


FIG. 8.—SHOWING WIRING FOR TWO-CYLINDER ENGINE WITH ONE COIL AND A DISTRIBUTER.

to provide some means of distributing this high tension current alternately to one or the other of the cylinders. This is done by means of a high tension distributer. The high tension distributer is very much like the low tension wipe contact maker, but has to be differently designed so that it will carry the higher voltage of current. The central wiper of this will be insulated, the high tension current being conveyed to it from the terminal F by an insulated wire and some form of spring insulated contact, generally a carbon brush. The wiper is shown at G. It travels round at half the speed of the en-

gine shaft, and as it does so comes opposite, every half revolution, to two insulated segments in an insulated ring, the segments being marked in our diagram H and J, and the insulated ring K. Segment H is metallically connected to one of the sparking plugs in one cylinder, while J is connected to the other, the sparking plugs being represented by H1 and J1. The high tension current is grounded from the coil at L.

If we follow this wiring out we shall see that the current flows from the positive terminal of the battery to the terminal A on the coil, through the primary winding of the coil to B, and from B to the two contact pieces on the contact maker P; so that, every time the wiper C of this contact maker makes contact with the two contact pieces D and E, the current will flow through the primary winding of the coil to ground, the wiper of the contact maker being in metallic connection with the engine. Every time this low tension current flows through the primary circuit the high tension current will be induced in the secondary winding of the coil. That is to say, the high tension current will be induced once in each revolution of the engine, because the contact maker only revolves once in every two revolutions of the engine and makes contact twice in each of its own revolutions.

The high tension current flows through the coil to the wiper of the high tension distributer G, and this also revolves at half the speed of the engine, so that every time the low tension contact maker makes contact the high tension distributer is also making contact with one or other of the two segments H and J; and so when it makes contact with J it will conduct the high tension current to the sparking plug J1 in one cylinder, while, when it makes contact with H, it will conduct or distribute the current to the sparking plug H1 in the other cylinder. The high tension winding of the coil being earthed at L, the current, whether it is sent to one or the other of the two cylinders, will flow back through the metal of the cylinder and car to the place where the high tension current is grounded at L.

This diagram does not illustrate a mechanism which is used

in all cars. The contact maker may be arranged quite differently, also the distributer, as far as its mechanical features go; but the principle is the same in all, and this principle governs the use of a single coil and trembler for any number of cylinders.

From this illustration it will be understood that wherever one coil only is used the low tension circuit must be made and broken every time a cylinder has to be fired, and the high tension current must be distributed by some form of distributer in rotation to the different cylinders. It may be said that in the case of a two-cylindered engine it rarely happens that the high tension distributer is used, as it involves the extra mechanical movement driven by the engine, which would be more expensive to manufacture than would be the fitting of one extra coil; but where four or more cylinders are used the synchronization obtained compensates for the extra mechanism, the expense of which is hardly increased by the number of cylinders which it is arranged to distribute to.

Coming back again to the system where a coil is used for each cylinder, and where four cylinders are to be fired, we will

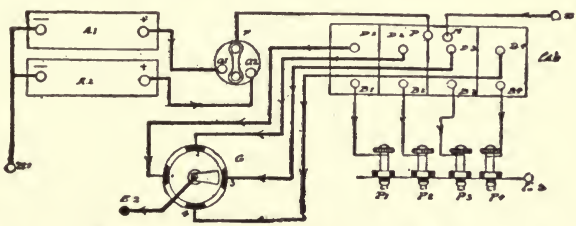


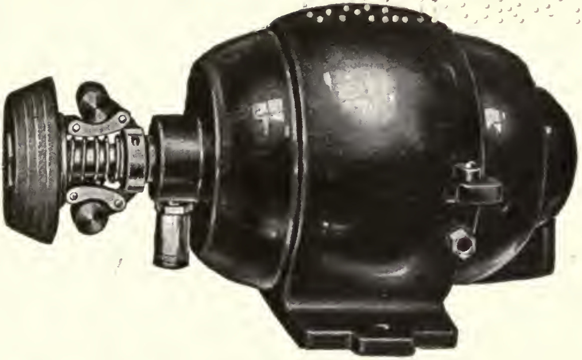
FIG. 9.—THE WIRING OF A FOUR-CYLINDER ENGINE WITH FOUR COILS.

describe a case in which two accumulators (storage batteries) are used, either of which may be put in operation at the will of the driver. This will enable us to see how this arrangement may be carried out not only in a four-cylinder engine, but in an engine of any number of cylinders. In Fig. 9 is shown the wiring of a four-cylinder engine where there is a separate induction coil to each cylinder, and where the low tension cur-

rent may be provided from one or the other of two accumulators. The accumulators shown at the left-hand of the diagram are marked A1 and A2. Both of their negative (—) terminals are grounded at E1. The current flows from the two positive (+) terminals to two terminals A1 and A2 on a switch. The switch is capable of connecting either of these to the terminal F on the switch. From F the insulated wire leads the current to the terminal P on the coil.

By the manipulation of the switch either accumulator A1 or A2 can be made to discharge the current to the terminal P on the coil. Inside the coil box the terminal P connects up to the primary winding of each coil, and from the primary winding of each coil the current flows by means of the terminals D1, D2, D3, D4, to the contact maker which is shown at G. On this contact maker are four segments marked 1, 2, 3, 4; these are completely insulated from the engine, and a central wiper, which rotates at half the speed of the engine, is arranged to come in contact with these four segments in turn. In the position shown, the central wiper is in contact with segment No. 3; and, therefore, with coil No. B3. Presuming the switch is connected to one or other of the accumulators, the current will flow through the switch at F, through the primary winding of the coil B3, out at terminal D3, through the segment and the rotating wiper, and to ground in the metal of the engine, forming a complete circuit. During the time that it is flowing it will be inducing a high tension current in coil B3, and this high tension current will flow from the terminal in coil B3, through the sparking plug P3, and so to ground in the engine. The other end of the high tension winding of coil B3 is connected to the terminal M, and flows to ground at E. This terminal M is common to the end of the secondary winding of all four coils.

During the time that coil B3 is in operation, it will be seen that no low tension current can flow through any of the other coils; but as soon as the wipe contact maker makes contact with any of the other three segments, it will cause the low tension current to flow through the corresponding coil, induce the



The Apple Ignition Dynamo.

Dayton 14-S. Switchboard.

Apple Storage Battery.

THE APPLE IGNITION SYSTEM.

The Combat Igniter.
(Storage Battery.)

Bosch Low-Tension Magneto for
Two-Cylinder Cars.

high tension current in that coil, and cause a spark at the sparking plug which is connected to that coil.

In the case of each coil there is a separate trembler, and it is necessary in this system that the tremblers should be so adjusted as to give the same rapid make-and-break as each other; otherwise synchronization cannot be insured. It is for the reason that it is rather difficult to adjust four different tremblers on four different coils to give sparks of the same value, so far as igniting the charge goes, that synchronized ignition with one coil has become popular with many manufacturers and, as we said before, while necessitating the use of another mechanical movement on the engine, it does away with the multiplication of coils, with the necessity of adjusting tremblers to synchronize with each other, and of various troubles connected with induction coils.

The two-way switch allows of either of the accumulators being put into action—one generally being used as a stand-by. With such a system, in case of the accumulators being partially run down, and firing being precarious, it would be possible, by connecting the terminals of the switch A1 and A2 and the switch lever F together by any suitable means—such as the interposition of a strip of metal—to use the two accumulators in parallel, in which case their amperage would be increased, but this would not, of course, increase their voltage. It is not an advisable thing to do, but in an emergency it might be the means of getting the car home. Sometimes, also, by coupling the batteries in series one may be able to get a car to run with nearly exhausted batteries.

Reverting again to synchronized ignition of a number of cylinders, we may refer to the case of a six-cylinder car using one coil and one accumulator; this is the method adopted in the Napier (Fig. 10), and in this, as in the example shown in diagram 8, there is only one low tension circuit.

The current flows from the positive (+) terminal of the battery A to the terminal P on the coil; it then flows through the primary winding of the coil and the terminal D, and is taken to a wiper on a wipe contact maker F. The rotating

part of this mechanism is geared so as to run at half the speed of the engine, a helical wheel on the shaft K driving it. It will be seen that it has six projections on its edge, so that the wiper comes in contact with it six times. It is connected to ground by a spring plate H, which insures a permanent contact between the rotating part and the metal of the engine. Every time that one of the six projecting parts of this contact maker comes in contact with the wiper blade the current flows from the battery through the low tension winding of the coil, and through the contact maker to ground, returning to the negative (—) terminal of the accumulator, which is also grounded.

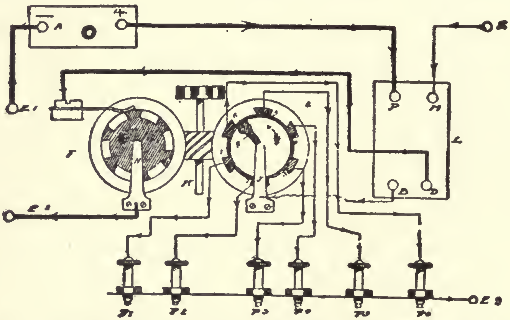


FIG. 10.—THE SYNCHRONIZED IGNITION SYSTEM OF THE SIX-CYLINDER NAPIER ENGINE.

Similarly each time this current flows through the primary winding of the coil the high tension current is induced in it, and thus flows from the terminal B to a central plate J, which is in contact with a rotating wiper R inside the high tension distributer.

On the outside ring of this are six insulated segments marked 1, 2, 3, 4, 5, 6, and as this central wiper rotates it comes opposite to each of these segments in turn. It is so geared that it comes opposite to one at the same time that the wiper on the contact maker F makes contact with one of the projecting pieces. Each of these segments in the distributer is connected to its own plug, and as the high tension current is induced at each one-sixth of a revolution of the distributer it flows to the plugs, the trembler on the coil causing the spark inside the

cylinder, into which is screwed the particular plug which is brought into circuit.

In the case of a high tension distributer it is not necessary that there should be absolute contact between the wiper and the segment; in fact, it is desirable that there should not be. Where contact is actually made, metallic dust, caused by the abrasion of the surfaces, sometimes gets incorporated in the insulating material, and causes metallic contact to be made before the wiper reaches the segment, owing to the high voltage of the current being distributed. In cases where contact is not made, the high tension current jumps across the very small space left between the wiper and the segments.

The Napier system of ignition has been slightly altered since the drawing of these diagrams, but in no way which affects the principle upon which it is based. For the newest arrangement of the Napier synchronized ignition, see Timing.

With slight variations, the systems which we have described cover the range as far as high tension ignition by coil and accumulator is concerned.

The mechanical arrangements of the contact makers and the contact breakers, and also of the high tension distributers, vary with different makers; but the principles involved are always the same, and an intelligent grasp of the examples given will enable a motorist to understand any ordinary system of high tension ignition.

The Lodge System.

Before leaving the system in which accumulators or batteries are used, it would be well to mention the device invented by Sir Oliver Lodge.

In describing the Lodge system of ignition, it will be necessary to explain the use and operation of the condenser, because the Lodge system of ignition depends entirely on the use of condensers in the high tension circuit. The condenser is used with all induction coils and with all magnets, so that the reason for its use may well be explained here.

We have pointed out that the spark at the gap depends to

a large extent on the suddenness with which electric contact is broken at the contact breaker or the trembler. The condenser is used to increase the rapidity with which the flow of current is stopped, and has also the advantage of reducing sparking at the contacts of the trembler. The current may be considered as having a certain amount of momentum—that is to say, it cannot be stopped suddenly. It is the effect of this momentum which causes it, when contact is broken, to rush across the gap in the spark plug, forming a spark. If this momentum can be absorbed, it is evident that the flow of current will be more quickly stopped, and it is the object of the condenser to absorb the momentum of the current in the primary, or low tension circuit, suddenly, and therefore the condenser is made part of the low tension circuit.

To explain how the condenser is inserted in a circuit, we might take as an instance the wire A B (Fig. 11), along which we will imagine current is flowing. If we put anywhere along

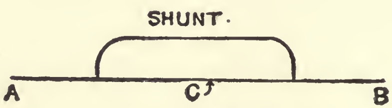


FIG. 11.—A SHUNT.

this circuit another wire leading from it and returning to it at another point, some part of the current will flow round this second wire, which is termed a "shunt." It is obvious that if we were to suddenly break the metallic current in the wire A B, say at C, the current would flow round through the shunt and get from A to B through the shunt wire. The condenser is arranged in this circuit provided by shunt wire, and is connected anywhere in the primary circuit so long as one connection comes before the trembler and the other comes after. That is to say, the condenser must be arranged in a circuit which will be complete independently of the making or breaking of contact at the trembler.

The condenser will not in itself form a complete metallic path for the current; otherwise it would always flow round through the condenser, and the making and breaking of con-

tact at the trembler would have no effect on the flow of current.

The condenser is formed of alternate layers of conducting and non-conducting material, the conducting material being tinfoil, and the non-conducting material being sheets of paper soaked in paraffin wax, or in some cases sheets of mica are used for the purpose. The use of tinfoil and this paraffined paper or mica provides very large surfaces for the conductors in a very small space.

In Fig. 12 the thick lines indicate the layers of conducting material of tinfoil, and the thin lines represent the non-conducting material which separates them. The alternate metallic conductors are joined together, which is indicated by the fine lines by which we have joined them up. They will be

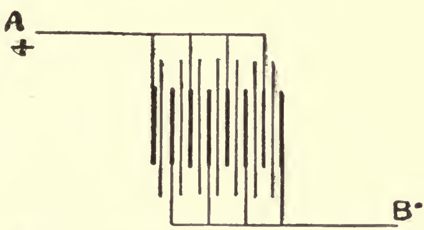


FIG. 12.—DIAGRAM OF A CONDENSER.

negative and positive alternately, all the positive being joined together and all the negative. Thus, it will be seen that in this arrangement the equivalent of two large plates or surfaces of conducting material face each other, but are insulated from one another by means of the paraffined paper. Suppose A were connected to the positive (+) terminal of some source of electric supply, and B to the negative (—) terminal, the arrangement of the tinfoil would enable the storing up of some of the electric energy, just as physical or mechanical energy—if we may use the term—can be stored up in a spring; and as the spring may be used to absorb the momentum of a moving body, so this condenser may be utilized to absorb the momentum of an electric current.

Now, supposing that this condenser is put in the shunt

circuit, Fig. 11, it gives a loop line between A and B. If the contact is suddenly broken at C, which is done by means of the trembler, the momentum of the current will be absorbed by the condenser, the result being that the stoppage or interruption of the flow of current by the interposition of the air gap at C will be very sudden and without sparking at the contacts. The momentum of the current has been absorbed in the loop representing the shunt by means of the condenser, so that the condenser enables us to get a better spark in the secondary, or, in other words, a more sudden stoppage of the primary current. Thus, the function of the condenser is not only to make a very sudden stoppage of the primary current, but also to stop it without sparking at the contacts of the trembler. Without a condenser there would be heavy sparking at the contacts of the trembler, causing rapid wear.

The condenser is used, as we have said, in every coil and in every magneto machine for electrical purposes, and in some cases, as in the case of some arrangements of De Dion ignition, the condenser is used in the contact breaker, the two ends of the condenser being shunted across the circuit at the contact breaker exactly in the same way as it is shunted across between the trembler points in the case of an induction coil.

In the case of the Lodge ignition the peculiar characteristics of the condenser are taken advantage of to give a very high-efficiency spark; that is to say, the ability of the condenser to absorb the momentum of the current is used in order to get a very high discharge very suddenly, in a similar way to that in which a very rapid discharge of power is obtained from a spring, although the pressure in closing the spring up might be applied slowly and gradually. This is a mechanical action which is taken advantage of in thousands of ways whenever an exceedingly rapid application of power is required. It can be obtained by first slowly compressing a spring and then suddenly releasing it. In the same way, by using a condenser, a considerable amount of electric energy can be stored up, which at the right time can be discharged with considerable rapidity. Sir Oliver Lodge has stated that the discharge from

the condenser in the Lodge ignition system takes place in less than a millionth part of a second.

In applying the condenser for the purpose of the Lodge ignition, it is placed in the high tension circuit. An ordinary induction coil is used; that is to say, ordinary as regards the wiring, but specially constructed as regards insulation for the particular work it is to do as far as the high tension circuit goes. This coil is arranged exactly as in the case of other ignition systems we have been discussing. The low tension current induces the high tension current in the secondary winding of the coil, and this high tension current is then conducted, not to the sparking plug, but to the condenser. There is no metallic connection whatever between the high tension circuit, which flows round the secondary wiring of the coil, and the circuit which includes the sparking plug. These are isolated from each other by means of the condensers, as we shall presently explain.

The condensers in this case are not the tinfoil and paper arrangements which are used in the ordinary coil, but consist of what are known as Leyden jars. A Leyden jar is a glass insulating cylinder coated inside and outside with tinfoil. These surfaces of tinfoil, which face each other, but are separated by the glass cylinders, are represented in the ordinary condenser by the tinfoil sheets separated by the paraffined paper or mica.

In Fig. 13 is shown in the very simplest form the arrangement of the Lodge ignition. The high tension current leaves the coils from the terminals A1 to B1, and makes metallic contact with the tinfoil in the two Leyden jars C and D, which act as condensers. From the other tinfoil sheets of the two Leyden jars the current is conducted to the sparking plug across which it will have to jump. What happens is this: as soon as contact is made in the low tension winding of the coil, a high tension current is induced in the secondary winding; as there is no metallic contact, the current is stored up by the Leyden jars or condensers, there being what we might almost term an enormous quantity of negative electricity in

one set of tinfoil surfaces and of positive in the other set. This electricity has gradually been stored up during the time that the current is flowing through the primary winding of the coil; but a time will come when so much electric energy will be stored up in the condenser that it will have to find some means of breaking out. It cannot pass across from the negative to the positive surfaces owing to the intervention of the glass cylinders acting as non-conductors, but it will be seen that the circuit from A1 to B1 is nearly joined across at the point A. A is a sparking gap in the open air, and according to the distance of the two balls at A away from each other, so will be the pressure of current necessary to be stored

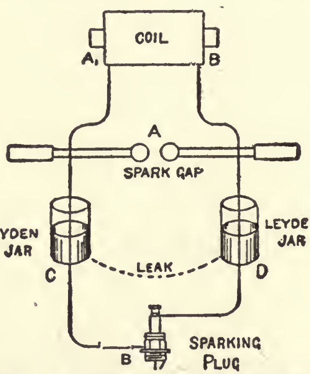


FIG. 13.—THE LODGE IGNITION.

in the Leyden jars before the current will jump the gap and so cause a spark. It will be seen that there is a leak or metallic connection across between C and D. This allows of the lower conductors of the Leyden jars being charged by induction from the upper conductors. When the stored up electric energy in the upper conductors of the Leyden jars reaches a certain point, the bursting pressure will be such that it will discharge across through the spark gap A. This discharge through A takes place with remarkable rapidity, as we have mentioned, but, as soon as it takes place, the stored-up energy on the other side of the Leyden jar surfaces will also be suddenly released, and will then violently jump across the points of the

sparking plug; that is to say, the positive electricity stored in one Leyden jar and the negative in the other will rush across and neutralize each other.

The characteristic of the sparks at A and B, which sparks have been termed by Sir Oliver Lodge the A spark and the B spark, respectively, is the ability to take the straightest cut even through a gap. Thus, when the discharge of the lower conductors of the Leyden jars takes place it is across the gap in the sparking plug and not through the leak. To quote another description of the Lodge ignition system: "The B spark is an impulsive rush of high pressure current surging across the spark gap with extraordinary speed and energy. A sparking plug that is flooded with oil, one that is wet all over (outside and inside the cylinder), or one that has its spark gap choked all up with carbon deposits—none of these are any hindrance to it whatever. The spark blazes across instantly, blowing all accumulations out of its path, and leaves a clear gap. It is a discharge that must take place somehow. Best of all, it likes a clear and simple metal path, along which it can freely surge, and if it meets a little gap midway—well, it just takes that too—no pause is possible. It has no time to choose a slower path of damp or dirt such as would entice away the ordinary high tension spark. It goes its own way in spite of all, not quietly and easily, but tears explosively over the gap in compression, setting fire to everything combustible it meets; and throwing all else aside."

Another remarkable feature of this particular spark is the ability to use it for clearing away any deposit of conducting material on the sparking plug points. Should the sparking plugs become foul from over-lubrication or other cause, they can be cleaned from the driving seat. The spark gap A is adjustable, and is arranged on the top of the case under a glass lid, which can be easily lifted. By simply screwing the two balls across which the discharge takes place a little further away from each other, the intensity of the spark is then so increased that any accumulations are blown off the points. The spark across the adjustable gap A can be observed through the

glass lid of the coil box, so that it can be easily seen whether ignition is taking place correctly, for unless the discharge takes place across the gap A no possible discharge can take place across the spark plug.

The whole of the apparatus is inclosed in a box shown in our diagram, Fig. 14. The spark gap is seen on the top. The current which is given off when the Leyden jars discharge themselves is carried by a highly insulated conductor away to the high tension distributer, which makes metallic contact

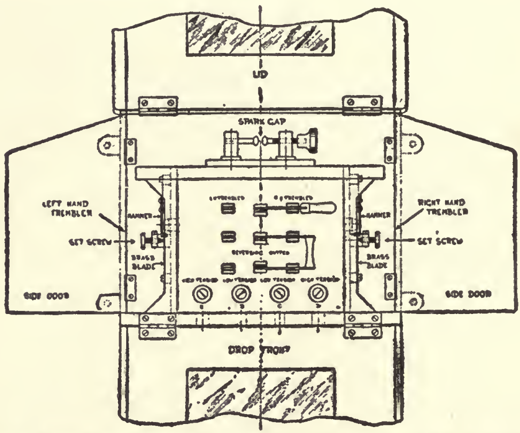


FIG. 14.—GENERAL ARRANGEMENT OF THE LODGE IGNITION APPLIANCE.

with the different plugs in proper order. In this diagram it will be seen that there are two tremblers, one on either side of the coil, and these can be easily got at by opening the side doors. These tremblers are both operated by the single iron core of the coil. The low tension current is taken to the top switch shown, and this switch puts the low tension current into contact with one or other of the two tremblers, so that either trembler can be used at the option of the driver. This arrangement is provided so that, in the case of one trembler getting out of adjustment, the other can be used until the necessary adjustment can be made. Although one trembler is only used for the make-and-break of the current, yet the

rapid alternations of magnetic and unmagnetic state of the core will cause both tremblers to be trembling whichever one is used for the actual making and breaking of the contact.

Another appliance is that for the reversal of the direction in which the current flows through the contact maker. This is accomplished by means of the reversing switch shown, and the functions of this will now be explained. However well made the contact points of a trembler may be, the fact remains that every time contact is broken between them a spark will pass; that is to say, some of the metal will become fused. What really takes place is that particles of fused metal on the positive contact will actually fly across and build up on to

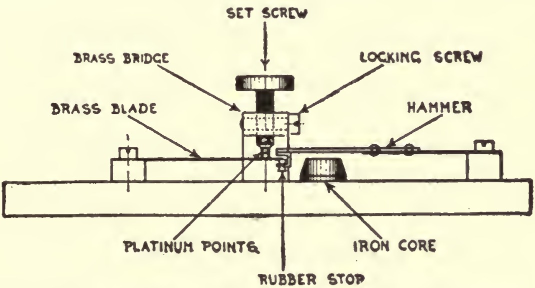


FIG. 15.—THE TREMBLER OF THE LODGE IGNITION COIL

the negative, so that the contact surfaces will not keep level. The result is a resistance to the flow of the current and a considerable pitting of the surfaces. The reversing switch allows of the making of either the trembler or the contact screw the positive element in the circuit. It has been found that by reversing the current the metal which is built up on the negative (—) terminal can be actually caused to pass back to what was the positive (+) terminal by reversing the direction of the current; and it is found that by reversing the direction of the current regularly once a day it is only very occasionally necessary to trim up the contact surfaces of the platinum points.

Considerable experiment has been necessary to get out a trembler which should give perfect timing at very high speeds. In Fig. 15 is shown the trembler used. The vibrating mechan-

ism of the trembler consists of two parts—the hammer and the brass blade. The brass blade carries the platinum contact point which makes contact with the point on the end of the set screw. The set screw allows of the adjustment of the two points relatively to each other, this adjustment being locked by the locking screw. The end of the brass blade is held in a stop piece at the end of the hammer. A little rubber stop is inserted in order to take up the impact. The hammer is an-

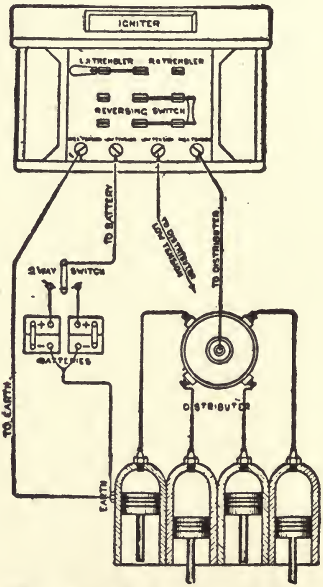


FIG. 16.—THE WIRING OF THE LODGE IGNITION SYSTEM.

chored at one end to the coil case by a spring blade. When the primary current flows across the contact points the iron core becomes magnetized and draws the hammer down. The brass blade being controlled by the stop on the hammer, it also has to move downward with the hammer, and contact is thus broken at the trembler points. The magnetism in the core then ceases, and the hammer resumes its normal position, taking with it the brass blade and again making contact at the contact points.

To understand how this system is wired up, we may refer to diagram (Fig. 16). Two batteries are used, and may be coupled to the ignition by means of a two-way switch. The current is taken by the wire shown to the terminal B on the coil, and then flows through the coil out through terminal C to the low tension contact maker, which in our diagram is called a distributer. In reality, it does not distribute the current, but its function is to make contact every time a cylinder has to be fired. The high tension current is taken from the secondary winding of the coil to the Leyden jars connected up inside the coil case. The high tension current discharge from the Leyden jars is taken from D and E, E being connected to ground and D being connected to the high tension distributer which distributes the current to the different cylinders. It will be seen that the wiring of the system is just as simple as that of any high tension system using a single coil and distributer, the connection of the high tension circuit to the Leyden jars being made up inside the appliance.

THE MAGNETO SYSTEM.

The next of the divisions into which we separate the systems of electrical ignition is the magneto method, and this can be subdivided into two sections, comprising the low tension and high tension systems. In dealing with ignition by dry batteries and accumulators, it will be remembered that we showed that the spark inside the cylinder can be obtained from a low tension current transformed into a high tension current. It is exactly the same with magneto ignition. We may use either a low or a high tension current, but, as in the case of ignition with dry batteries or accumulators, whenever the high tension ignition is used we must have a low tension current to induce it in an induction coil.

In both systems of magneto ignition the low tension current is generated in the same way, the appliances for this differing principally in constructional details and in the method of wiring up, and the high tension system, as far as magneto methods go, in that provision is made to cause the low tension current generated in the machine to induce a high tension

current. For this purpose an induction coil, either separately or incorporated in the machine, becomes necessary.

Low Tension Magneto Ignition.

This being understood, it will be well to deal first with the low tension magneto. That once being thoroughly comprehended, the apparent complication of the high tension system will become quite simple. The principle on which the method is founded lies in the fact that if a coil of insulated wire be revolved between the ends of a magnet, the magnetic influence will so act as to cause a current of electricity to flow through the coil, this being of low tension, and being of a nature suitable for ignition either on the low tension system inside the cylinder or to induce a high tension current in some form of induction coil.

The diagram, Fig. 17, shows the permanent magnets used in a magneto. They are of highly magnetized hardened steel,

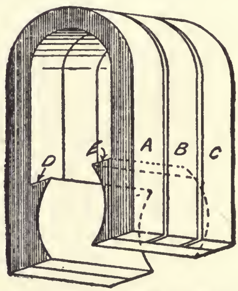


FIG. 17.—THE MAGNETS OF A MAGNETO MACHINE.

and are generally arranged in pairs, three sets of pairs being used. These are shown at A, B and C. The efficiency of the machine depends in a large measure on the extent to which the horseshoe magnets A, B and C are magnetized. The arrangement of the magnets in horseshoe form is the most convenient for the purpose of getting the coil, which we wish to revolve, well surrounded by the magnet ends, which are for convenience provided with two soft cast-iron pieces D and E in close metallic contact with the ends of the magnets and

forming a kind of tunnel inside which the coil or armature will revolve. These two pieces are termed the field pieces and are often spoken of jointly as the magnetic field.

If a soft iron core of a cross section of the shape shown in Fig. 18 is taken and a winding of insulated copper wire is

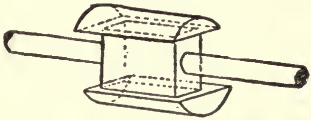


FIG. 18.—THE CORE.

wound around it as shown in Fig. 19, we shall have a coil which is of a convenient shape to be revolved inside the ends of the magnets; that is to say, it will occupy a position within the magnetic field. The object of having this coil revolving is to cause the magnetic influence, or the lines of magnetic force, as they are termed, of the magnets to pass through the

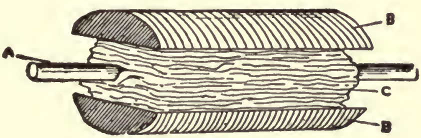


FIG 19.—THE ARMATURE.
A, Armature spindle.
B, B, Iron core of armature.
C, Coil around core.

coil alternately from different directions. This core around which we wind the insulated copper wire is known as the armature.

Fig. 20 is a diagram of the ends of the magnets, and a cross section of the armature in position. AC is the armature core, and C is the winding of insulated wire around it. F and M are the field magnets or permanent magnets, and the south pole of these is at S, the north pole being at N. What effect the position of the armature with its coil, inside the magnetic field will have on it, in an electrical sense, we will next endeavor to explain as simply as possible.

In describing the soft iron core of an induction coil, we

showed that, when a current of electricity was passed along a winding of insulated wire around the core, the latter became for the time magnetized. A reversal of this idea may be regarded, for the sake of argument, as what takes place in the case of the magneto. Here there is a soft iron core and the winding of insulated wire around it. If, now, we can make this soft iron core a magnet, we can, in a certain manner, induce a current of electricity in the winding around it, but this

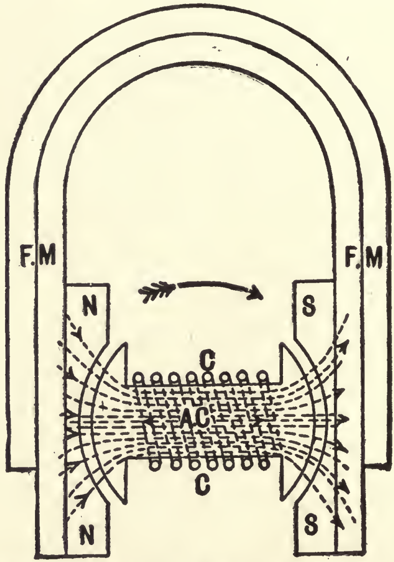


FIG. 20.—LINES OF FORCE PASSING THROUGH THE CORE OF THE ROTATING ARMATURE.

depends on the fact that, to get any results from the induced current in the winding, we must keep reversing the direction of the polarity of the core or armature C. In the case of the soft iron core of an induction coil the polarity, that is to say, whether the north pole shall lie at one end or the other, is determined by the direction in which the wire is wound around the core, and is always the same, there being no practical value or advantage in altering the polarity of the core; but in the present case, in order to get an inductive effect, we may re-

verse the polarity of the core, or we may cause it to intermittently become magnetized, and this can be done by revolving it between the field pieces. The magnet acts on the soft iron core or armature A C, giving it a magnetic pull which is apparent to the touch, if the armature is allowed to move freely towards the field which is trying to attract it. This it can do when the bearings which hold it centrally are dismantled. This force is represented in our diagram by lines, these lines indicating the direction in which the force acts.

The direction of these lines shows us that the magnetic force is similar to electrical force in that it will always try to act in a direction in which there is the greatest body of metal capable of being magnetized interposed between the

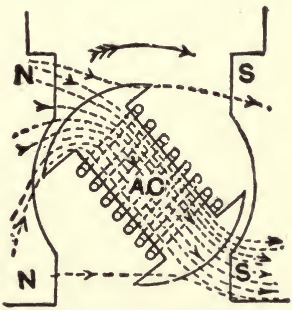


FIG. 21.—LINES OF FORCE IN THE ACT OF BEING CUT.

two field pieces of the magnets. With the core placed in the position shown in Fig. 20 it will be seen that the lines of force are acting as indicated by the dotted lines; that is to say, the magnetic force is acting straight through the center of the armature, and thence through the winding of the coil. Supposing now we rotate the core in the direction of the arrow until it assumes the position shown in Fig. 21, it will be seen that the lines of force have gradually changed their direction. They are still flowing through the greatest body of metal of the core, but they cannot get across in such a direct manner, the direction of the lines of force being indicated by the dotted lines. In fact, there is a kind of leakage, some of the lines of force flowing across between the fields without

passing through the armature core, as indicated by the two separate dotted lines.

If the armature is rotated a little further to the position shown in Fig. 22, it will be seen that the lines of force flow across the bulk of metal which forms the sides of the H section of the armature, and do not pass through the center of the armature at all. That is to say, they are not passing through the center of the coil of insulated wire, so that, in fact, stoppage of any magnetic effect on the core has been accomplished by the mere rotation of the core for one-quarter of a revolution in the field. If we rotate the armature another

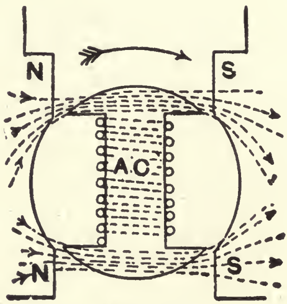


FIG. 22.
LINES OF FORCE PASSING DIRECTLY THROUGH THE ENDS OF THE ARMATURE FROM NORTH TO SOUTH POLE.

quarter of a revolution in the same direction, it will assume exactly the same position as shown in Fig. 20, but with this important difference, that that part of the armature which was close to the south pole of the magnets now finds itself close to the north pole; so that the direction of the lines of force have been first taken altogether away from the center of the core and then completely reversed relatively to the core itself. It is evident, therefore, that the armature is changing its polarity once every revolution in the field, and it is this constant change of direction of the lines of force through the core that induces the current in the winding around the armature, which current we make use of for ignition purposes.

As the armature A C wound with the copper conductors or coil rotates between the two poles of the magnet N S it cuts through the lines of force or magnetism which pass from one pole to the other, and as a result a current is induced in the coil of the armature. When the armature rotates through the position as in Fig. 22, it will be seen that the conductors are cutting the maximum amount of lines of force, and, therefore, this is the point at which the current is at its maximum value. As it continues to rotate the current value gradually decreases, and after a quarter revolution (when it is in the position as shown in Fig. 20) when its conductors are, as it were, slipping along the lines of force, and not cutting any, its value is nil. Then it again gradually grows to a maximum in the reversed direction (when the armature is again in position as shown at Fig. 22) and as before, falls to zero, and so on, rising to a maximum and falling to zero twice in every revolution of the armature.

But something else has also been done by this reversal, for it will be found that we have changed the direction of the electrical current flowing through the winding; thus we have an alternating current in the wire. If we were to connect the two ends of the wiring C round the armature, and to rotate the latter at a good speed, we should not get a constant flow of electricity through the wiring, but an intermittent one, that is to say, the voltage of the current would start from zero and gradually rise as the armature revolved and then as rapidly fall. Two of these, which we may call waves of current, take place during each revolution of the armature, and if we break contact in the winding around the armature at the time when the electrical wave is at the highest voltage, we shall be able to get a spark.

It is the object of the low tension magneto system to lead this current generated in the armature winding to the inside of the cylinder and to break the contact there, and if that can be done an efficient spark for ignition purposes is produced.

A Simple Form of Magneto—A very simple low tension

magneto system is shown in diagrammatic form in Fig. 23. One half of the magneto has been cut away in order to show the armature A lying adjacent to the field B. The coil of insulated wire around the armature is shown at C, while D is the armature spindle upon which it revolves in bearings fixed to either end of the field pieces, the shaft being driven at one end by a gear wheel which causes it to revolve at some speed relative to the engine speed. It generally runs at half the speed, but, in the case of multi-cylindered engines, it becomes necessary that it should run at such a speed as will give a diversion of the lines of force at least once every time a cylin-

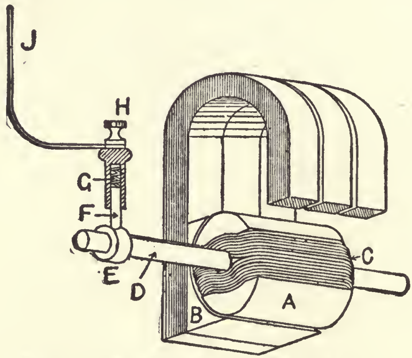


FIG. 23.—DIAGRAM OF A MAGNETO.

der has to be fired. One end of the winding of the coil C is directly and metallically connected to the armature shaft, which, of course, grounds it. The other end is brought out and attached to an insulated ring E, which is fixed to some part of the armature or its shaft and revolves with it, but has no metallic connection with it. On the outside edge of this ring, and pressing down upon it, is a carbon brush or wiper F, contained in a tubular case and pressed down by the spring G. The casing which holds this carbon brush or wiper is suitably insulated from any metallic part of the machine, and carries a screw terminal H. It is from this terminal that the current is taken off by means of the insulated wire J and conveyed to the mechanical contact breaker inside the engine cylinder.

The Low Tension Igniter—The contact breaker inside the cylinder for use with this type of magneto is arranged in a variety of different ways, according to the ideas of different designers. Its object is first to keep the circuit open, but just before the armature reaches the position shown in Fig. 26 to make contact, and then suddenly break it when the armature is in the position shown. If contact were made all the time there would be no induction set up in the coil, as may be easily understood by the fact that if we ground the winding to the magneto we stop its operation for sparking purposes. Another point is that in the case of multiple cylinder engines it is necessary that only one contact breaker should be making contact at the same time.

In Fig. 24 is shown one arrangement, by means of which contact can be made and broken inside the cylinder. A is

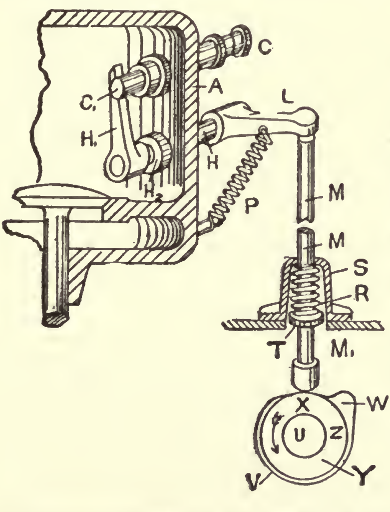


FIG. 24.—LOW TENSION IGNITER.

A, Cylinder.
C, C1, Igniter plug.
H, Rocking spindle.
H1, Contact arm.
H2, Conical joint.
L, Lever on H.
M, M, Tappet rod.
P, Spring.
R, Spring.
S, Thimble over spring.
T, Collar.
U, Cam shaft.
V, Concentric part of cam.
W, Cam projection,
X, Lowest contour of cam.
Y, Cam.
Z, Cam face.

the cylinder in section, so as to show that part of the contact breaker which is inside it, as well as that part which is outside it. Through the wall of the cylinder A passes an insulated plug C, having at its outside end a terminal and terminating inside of a cylindrical piece C1 of steel. This cylindrical piece is insulated from the cylinder by means of the insulation of the

plug. The low tension wire from the magneto leads the low tension current to the plug C. H is a rocking spindle, which also passes through the walls of the cylinder. Inside at H_2 it is provided with a tapered ground joint, so that the pressure inside the cylinder will always keep it gas-tight, yet at the same time it can rock in the joint. On its end, inside the cylinder, it carries a lever H1, known as the contact arm. This lever, as will be seen, is so arranged that it can come up in contact with the insulated plug C1. At its end, outside the cylinder, the rocking spindle H carries a second lever L at right angles to the lever H1. A spring P is interposed between this lever and a pin on the cylinder, and this spring keeps the lever L pressed down, and therefore tends to force the lever H1 in contact with the insulated plug C1. This is the normal position of this lever, except under conditions which we shall next describe.

On the engine camshaft U, which is shown in end view, is mounted an ignition cam Y. The shape of this cam is of importance to the operation of the appliance. There is a tappet rod M which passes through the crank case, and at its end carries a hardened shoe M1. It also has a collar T, and is inclosed partially in a thimble S, which is screwed down on to the crank case. Between the collar T and the top of the thimble S is interposed a compression spring R. Obviously this spring will keep the shoe M1 down into contact with the outside of the cam Y. The top of the tappet rod M is arranged to come just under the end of the lever L. The configuration of the cam Y is such as to give this tappet rod a variable movement up and down. In the position shown the shoe is on that portion of the cam which is concentric with the circle Z, which may be described as the lowest part of the cam. In this position it will be seen that the top of the tappet rod M is not in contact with the end of the lever L, so that the spring P can draw the contact arm H1 into close contact with the plug C1. It is just at this position that contact is made, and is about to be broken. The cam Y rotates in the direction indicated by the arrow, so that, after it has rotated

a little farther than the position shown, the shoe M1 is suddenly forced up by the projection W on the cam. As it rises it will also knock the end of the lever L up, and therefore will move H1 out of contact with C1, thus breaking contact and firing the charge in the cylinder. The cam continues to rotate, and the shoe gradually drops again as it comes back upon the lower part of the projection W until it reaches that part of the cam V, which is concentric with the shaft, but of large enough diameter to keep the shoe M1 lifted high enough to keep the lever L lifted up and H1 out of contact with C1. During the rotation of the cam the contact breaker is held in this position until it reaches that part of the cam again when the tappet rod M drops, and allows contact to be made, only to be again broken by the projection W on the cam.

The Fiat Igniter—The illustration (Fig. 24) is purely diagrammatic. A drawing of an actual low tension igniter on practically the same lines is shown at Fig. 25, and the same index letters have been applied to this as in the case of the diagrammatic view, so that the reader can refer from one illustration to the other in order to grasp the details of the arrangement. In Fig. 25, the cam operating the rod M is not shown. It is, however, in construction substantially as illustrated in Fig. 24.

The low tension current is led by the insulated wire F to an igniter or plug G1, made of steel, and passing through the walls of the cylinder. It is insulated from the latter by the two cone insulating collars C and C. By means of the nut E, and the two washers D and D, these two coned insulators can be drawn towards each other, forming a gas-tight joint.

The plug G1 is thus entirely insulated from the cylinder wall, but it is in metallic connection with the insulated coil around the armature of the magneto, through the medium of the insulated wire F. It is necessary in order to complete the circuit for the low tension current that some means should be provided for putting the igniter plug G1 into contact with ground, and at the same time providing a means

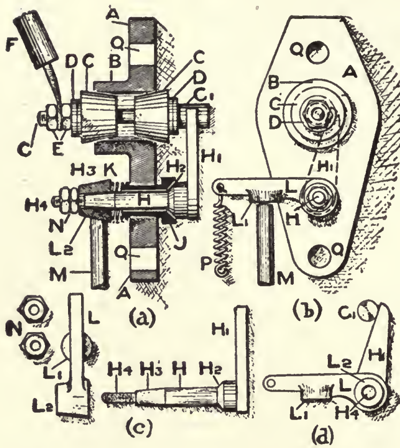


FIG. 25.—THE F.I.A.T. LOW TENSION IGNITION CONTACT BREAKER.

A, A, Plate upon which the ignition device is mounted.

B, Boss bored to take igniter, G, G_1.

C, C, Composition insulating blocks, tapered to form air tight joints.

D, D, Asbestos and brass washers.

E, Nuts for pulling up insulating blocks C, C, and also for attaching the high tension cable F to the igniter G, G_1.

F, Wire from magneto.

G, G_1, Igniter, the end G_1 being larger in diameter than the end G, thus forming a shoulder for the nuts E to pull the insulating blocks up to cover plate.

H, Rocking shaft.

H_1, Contact arm forming portion of H. When contact is broken between H_1 and the end G_1 of the igniter, a spark occurs.

H_2, Conical facing, forming an air tight joint on the seating in bearing piece J.

H_3, Tapered portion of H.

H_4, Screwed portion of H.

J, Bearing piece, in which is formed the seating for H_2.

K, Light spring, keeping H_2 up to its seating in J.

L, Actuating lever, by means of which contact between H_1 and G_1 is broken.

L_1, Small boss or facing, against which the tappet or lifting rod M acts.

L_2, Boss of actuating lever L.

M, Tappet rod.

N. Nuts, screwed on to the end H_4 of H, holding the boss of lever L in position on H by binding it on to conical portion H_3 and by means of which the adjustment of the angle between L and H can be made.

P, Spring attached to the actuating lever L, tending to keep H_1 and G_1 in close contact.

Q. Bolt holes, for attaching the ignition device to cylinder.

for breaking this contact at the moment when firing in the cylinder is to take place.

This is done by means of the arm H1. This arm is fixed at the end of an oscillating spindle H, which passes through a bearing J in the walls of the cylinder. The outer end of this oscillating spindle is provided with a second lever L, this lever being on the outside of the cylinder. It will be seen that if L is lifted or depressed H1 will also be moved inside the cylinder. The top of the lever H1 is brought into contact with the end of the plug G1, by means of the spring P, at the end of the lever L. This spring holds L down and causes H1 to keep in contact with G1. The low tension current from the magneto can then flow through G1, through the lever H, and to earth through the cylinder walls. M is a vertical tappet rod, its bottom end being in contact with the edge of a cam on the engine camshaft.

What happens so far as the mechanical break goes is this: The cam normally keeps M in contact with the boss L1, on the lever L, and keeps this lever lifted just enough

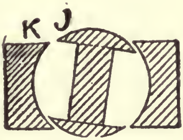


FIG. 26.

to keep H1 out of contact with G1. Just before it becomes necessary to fire the cylinder, however, the cam allows M to drop out of contact with L1, the spring P draws L1 down and causes H1 to be pressed in firm contact with G1. This takes place just at about the time when the armature is in the position shown in Fig. 21 relatively to the field. As the piston comes to within a very little distance of the top of the stroke and just when the relative position of armature is as shown in Fig. 26 (that is to say, the lines of force have just been diverted, and the edge J of the armature has just left the edge K of the field) the cam suddenly forces the tappet rod M upward; thus M strikes L and lifts it, and consequently

breaks contact between H1 and G1. The greatest inductive effect is then taking place in the winding on the armature, and the sudden breakage of the circuit causes the sparking to take place and the gas charge to be ignited.

Very numerous are the mechanisms for breaking contact inside the cylinder, the type we have described being only one of the number. There is one point which ought to be made quite clear. It is obvious that if we had a number of cylinders to fire, say 4, and seeing that all the insulated plugs are in circuit with the low tension wiring around the armature, if the contact between H and G1 were made all the time, and only the breaking were depended on at the time of ignition, it would happen that when one contact breaker in one cylinder was breaking contact, the other might be in contact, with the result that the current would flow through the latter and not jump the gap made by that igniter which had just broken contact. It is, therefore, the function of the cam operating the tappet rod to first put the two into contact, so that the current can flow to ground just a moment before the spark has to take place, and then to immediately break the contact. Normally, in all these appliances, the two conductors are not in contact, so that the device may be very accurately termed a contact maker as well as a contact breaker.

An Emergency Arrangement—In the case of an engine having the mechanical contact breaker inside the cylinder a simple form of stand-by ignition can be adopted, so that in case of any derangement of the magneto the cylinders can be fired in the usual way. In Fig. 27, A is a coil having a soft iron core, and having around this core a considerable winding of insulated wire. The wiring terminates at either end in the terminals B and C, and the current then travels by way of the switch D to the insulated plug in the cylinder at F; the switch D is for the purpose of putting the appliance in or out of operation at will. The current is supplied by the battery G, instead of from a magneto. One terminal of this is connected to the winding inside the

coil A. It will be seen that the circuit is from the battery, through the coil, out by the terminal C, to F, the other terminal of the battery being grounded at E. As soon as the engine makes contact inside the cylinder by means of the contact breaker the current flows through the coil, passes across the contact points, flows to ground in the engine, and back to the battery by the battery ground wire E. Just at this moment the engine breaks contact inside the cylinder and a spark occurs. It will be seen that this appliance can be easily fitted up, it only being necessary to connect the coil A to the low tension ignition plugs of all the cylinders. The engine itself, by virtue of the four contact breakers,

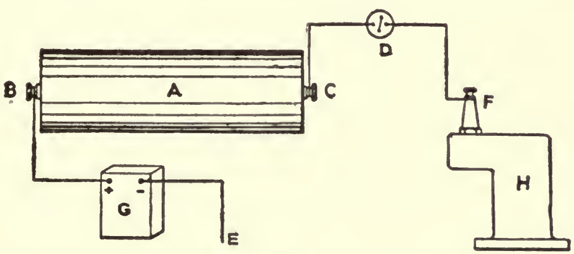


FIG. 27.—A STAND-BY SYSTEM WHICH CAN BE USED IN CONJUNCTION WITH LOW TENSION MAGNETO IGNITION.

A, Low tension coil.
B, Connection to positive terminal of accumulator.
C, Connection to switch.
D, Switch.
E, Earthed connection of accumulator.
F, Igniter plug in cylinder.
G, Accumulator.
H, Cylinder of engine.

acts as a distributer, and each cylinder takes its current and breaks contact in its proper order.

A Magnetic Contact Breaker—A new type has been recently introduced by the Bosch company. In this the make-and-break inside the cylinder is operated magnetically. The great advantage of this system is that there is no necessity for specially designing the engine in order to provide tappet rods and other mechanical features to break contact inside the cylinder. The magnetic contact breaker may be screwed into the recess usually occupied by the ordinary sparking plug, and is provided with a low tension current from a low

tension Bosch magneto fitted with a contact breaker and distributer.

In our illustration, Fig. 28, we show a cross section of the plug. Referring to this cross section, we see that there is a terminal on the top of the plug to which the wire from the magneto is led, and it is this terminal that takes the current, which is circulated round a winding of insulated wire and around a core situated round a rocking armature. This winding of wire, when the current is sent through it by the mag-

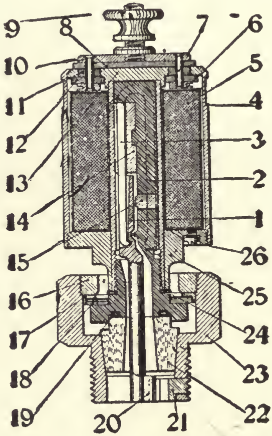


FIG. 28. — THE BOSCH MAGNETIC PLUG IN SECTION.

neto, causes the core to become magnetized, and it is the attraction of the armature to it which effects the make and break in the following way:

1 is a lever known as the interrupter lever; it rests on a steel knife edge. At its lower end at 20 it is in contact with a contact piece 21, by means of which it is grounded to the body of the engine. To keep 20 and 21 in contact with each other a U-shaped spring 3, shown partly in outline and partly by dotted lines, is used. It will be seen that one end of this U-shaped spring rests in a recess just below the point at which the interrupter lever is pivoted on the knife edge. Only a very slight movement of the spring is

necessary to keep the two contact points 20 and 21 in contact with each other. The upper part of the interrupter lever 1 forms the armature, and the central part upon which it is pivoted on a knife edge forms a pole piece, but it must be understood that the interrupter lever is insulated from the pole piece of the electro-magnet formed by the coil 5. Normally, the U-shaped spring presses the interrupter lever 1 in contact at 20 and 21, thus grounding the magneto. At the time of sparking a current flows through the coil 5; this energizes the pole piece 2, with the result that the top part of the interrupter lever is drawn toward it, its bottom end thus breaking contact between 20 and 21. The top of the interrupter lever is not allowed to touch the pole piece 2, and is insulated magnetically by means of a small brass separating piece 15, up against which it is pulled when contact is broken. The magnetic pole piece 2 is purely for the purpose of being magnetized by the coil 5, and it is not in metallic contact at all with the body of the plug 23, which is screwed into the top of the cylinder. It is insulated from it by a tapered plug of statite 22 and by mica washers 18, secured in position by means of the packing collar 16.

In order to follow the wiring, it must be understood that the low-tension current from the magneto is taken to the terminal 9. This is insulated from every other part of the plug except the ring 6, from which the current is taken to the coil 5, and is grounded from the coil by means of the screw 26, which is in metallic contact with the metal part inside which the armature is carried. It thus allows the current to flow through the interrupter lever 1 and to ground in the body of the plug 21, but the moment it commences to flow the coil 5 becomes energized, magnetizes the central core or pole piece 2, draws the armature or interrupter lever toward it, and breaks contact across between 20 and 21.

The magneto which is used in conjunction with this plug provides a low tension current only, but it is provided with a distributer which will distribute the low tension current to each of the magnetic plugs in turn. It is also provided

with a contact breaker, which will break contact each time the current has to be sent through one or other of the magnetic plugs. The advantage of the system is also shown in the fact that no high tension wires necessitating thick insulation are required, while spare plugs may be carried in case of any damage to, or derangement of, the plugs in use. It is necessary, however, that the plugs should be kept in as cool a position as possible on the engine. The contact between 20 and 21 is a V, and there is some side-play allowed on the interrupter lever, so that should one side of the contact become charred or carbonized it will be automatically forced to the other side and make contact. Experience has shown that in this respect the plug contacts are practically self-cleaning.

High Tension Magneto Ignition.

All that we have said under low tension magneto about the revolving armature in the field holds equally good as regards the high tension device, but in this case the low tension current generated in the armature is used to induce a high tension current in an induction coil, the current being used to jump across the gap in an ordinary sparking plug, doing away with the necessity for any contact breaker inside the engine. The magneto appliances in this system vary a great deal in minor details, especially as regards the mechanision current from the armature is sent to an induction coil of the ordinary type, which may be placed in any convenient position on the car, and is really a separate and complete appliance independent of the magneto. We may quote two examples, the Simms and the Eisemann, and a description of these will be sufficient to enable the reader to grasp the principle on which all these machines are constructed.

The Simms high-tension magneto utilizes the low tension current in the armature itself to induce the high tension current in a second winding around the armature. The armature thus fulfills the double purpose of producing the low tension current which, in turn, induces the high tension current for firing purposes. It will be seen that in this case the

armature is a complete induction coil in itself, having its primary and secondary windings and its soft iron core. The appliance also incorporates the high tension distributer, so that it is a complete electric ignition system in one unit, and only requires to be coupled up to the engine.

In the case of the Eisemann ignition the magneto only supplies the low tension current, there being but a single winding on the armature. This current is then led away through the primary winding of a separate induction coil which induces the secondary or high tension current for sparking purposes. In this type, in addition to producing the low tension current, the machine also acts as a snychronized distributer, the high tension current from the induction coil being led back to the magneto and from that distributed to the different sparking plugs in turn. The advantage of this system, as we shall presently see, is that the production of the low tension current, and its sudden break or interruption, and the distribution of the high tension current induced in the coil to the plugs in turn, are made to take place absolutely at relative times to each other under all conditions. Hence where we have the magneto generating the high tension current to jump across the ordinary sparking plug, we must have a separate contact breaker for the low tension current. Of course, in this case we need no contact breaker inside the engine; the magneto is, therefore, provided with a contact breaker, forming part of its mechanism, the function of which is to break the contact in the low tension circuit.

Before proceeding to describe the working of the high tension magneto, we might say that there is another system in which, like the Eisemann, the magneto generates only the low tension current to induce the high tension current in a separate coil; but in this case the magneto does not act as a high tension distributer, this function being performed by a separate part of the engine mechanism. As an example of this, we have the De Dion system. In this there is simply a rotating armature in a magnetic field with a low tension winding upon it. The current from this is led to a

separate induction coil, and contact is broken by a contact breaker on the engine and forming part of its mechanism. The high tension current generated in the coil is then taken to a high tension distributer on the engine and distributed to the sparking plugs in turn. The advantages of this system are a simplification of the magneto and great facility in applying a dual system of ignition, by using the contact breaker and the distributer on the engine and the coil as units of a separate ignition system in which the current is generated in a dry battery.

The Eisemann System.—In this system the low tension current is taken away from the magneto and used to induce

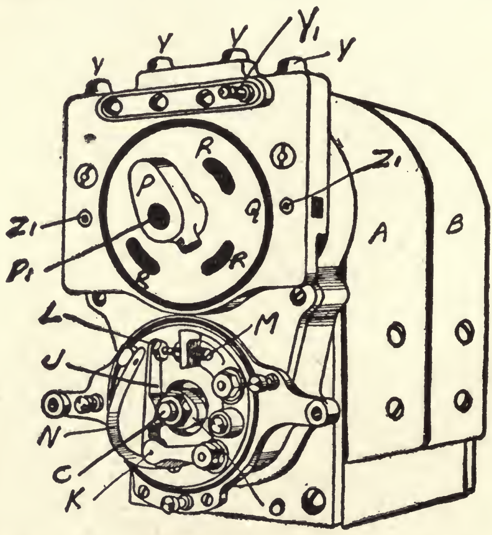
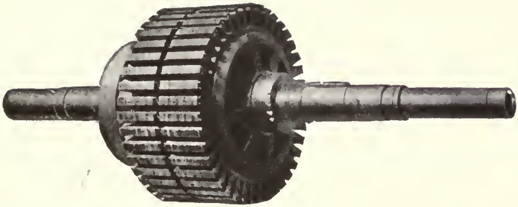
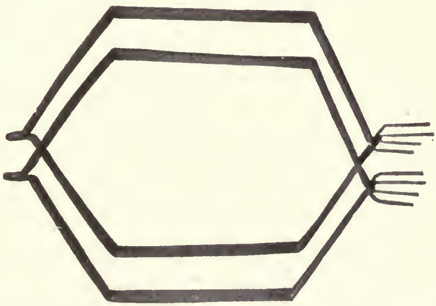


FIG. 99.—FRONT VIEW OF THE EISEMANN MAGNETO.

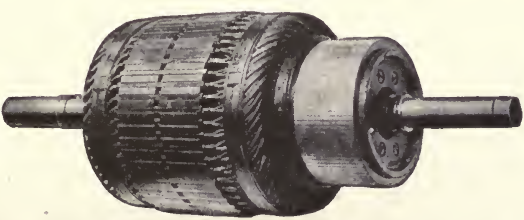
a high tension current in the secondary winding of an induction coil. This high tension current is then brought back from the coil to be distributed by a distributer forming part of the magneto mechanism. There are several types of this magneto used; they vary generally in their mechanical details, but in principle are all practically alike. In the first place, as regards the armature, this runs on ball bearings in



Armature Core, Assembled, Ready to Be Wound.



Two Armature Coils, Formed, Taped and Insulated, Ready to Be Wound on the Armature Core.



Completed Armature, Wound and Ready to Put Into Machine.

plates affixed to the end of the field pieces, the plates being of some non-magnetic metal. A front view of the machine is shown in diagrammatic form in Fig. 29. The magnets are shown at A and B, and the armature revolves inside between the ends of these, the end of the armature shaft being seen at C. If we look now at Fig. 30 we shall understand how the different units of the magneto are built uq. C is the end of the armature shaft. The latter revolves in ball bearings in the end plates and carries the wheel D; this wheel

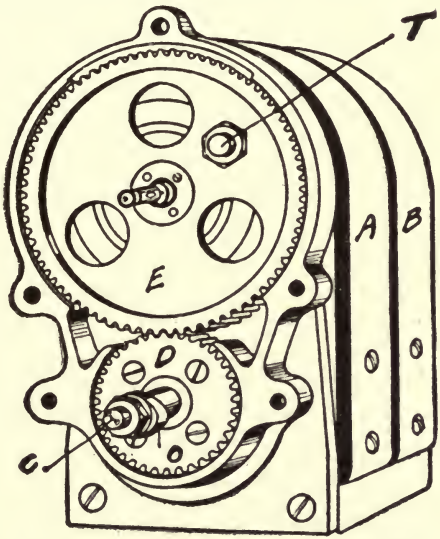


FIG. 30.—THE GEAR WHEELS WHICH OPERATE THE HIGH TENSION DISTRIBUTER.

gears with the second wheel E, which is mounted on a second shaft carried in bearings inside the space formed by the horse-shoe magnets A, B. The rotation of the magneto armature will rotate E at half the speed of the shaft. It is the function of E to act as a high tension distributer in a manner which we shall describe later. The contact breaker is mounted on a plate shown in Fig. 29, and consists of a pivoted arm J which is pivoted at K, and is L shaped. At its top end it has a small platinum-pointed head L which

comes into contact with the platinum-pointed contact screw M, capable of adjustment, and to which the current is led from the primary winding of the magneto armature. A spring N keeps the pivoted lever J pressed up so that contact is made between L and M. On the end of the armature shaft there is a cam O. (This cam is seen more clearly in Fig. 30, where it is not confused with the mechanism of the contact breaker.) Now, at the time that the armature is just cutting the lines of force in the magnetic field, this cam comes up against the lever J and knocks it out of contact with the insulated contact screw M, so that the circuit is broken at this moment.

The current from the low tension winding is taken through an insulated contact piece C on the end of the armature shaft, and passes to a carbon spring brush on the cover of the contact breaker, and from there to the platinum screw M of the contact breaker. This carbon brush is also connected to the primary winding of the coil. Thus normally the path of the low tension current is through the contacts of the commutator to ground, through the cam O and the armature, which is connected to ground by a spring-pushed contact piece, not shown in our illustration. This is really to insure a thorough contact to ground. At the moment of breaking the contact the current passes from the carbon brush to the low tension winding of the induction coil and then to ground.

The high tension current is now generated in the separate coil, and is returned by means of the insulated wire to the high tension distributer, also part of the magneto. This is shown very clearly in Fig. 30. At the end of the shaft, on which is mounted the wheel E, is mounted a rotating arm P (Fig. 29). This arm is insulated from the shaft and to it is conveyed the high tension current from the coil. It is the object of this rotating arm to distribute in rotation the high tension current to the different cylinders, which it does in the following way. The current is led to it by means of a terminal Y2 on the cover, which is shown in Fig. 31. This cover encloses the high tension distributer. The two spring

fasteners Z, Z engage in the holes Z1, Z1 (Fig. 29). In the center of the cover, Fig. 31, is shown a spring-pushed contact piece G pressed forward by the spring G1. This is insulated from the cover, but is in metallic contact with the terminal inside Y2. When the cover is in position, G presses up against the contact piece P1 (Fig. 29), in the rotating arm P, and thus the high tension current is led to P, which revolves in front of an insulated disk Q. In this disk are inserted four segments R, R, R, R and a spring-pushed wiper inside the end of the arm P, and pressing against the vulcan-

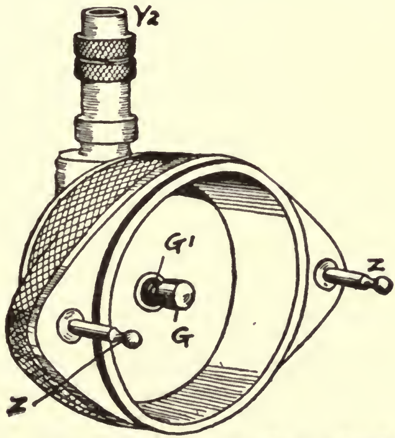


FIG. 31.—THE COVER OF THE HIGH TENSION DISTRIBUTER.

ite disk Q, makes contact with each of these four insulated segments in turn. These segments are internally connected up to terminals Y, Y, Y, Y on the top of the plate S, and from these terminals wires run to the different sparking plugs. It will be seen that this arrangement will distribute the current alternately to each of four cylinders. In the case of a two-cylinder engine or a six-cylinder engine there would have to be two or six respectively of these insulated segments, and in the case of a six-cylinder engine the ratio of gearing between the magneto and the engine would have to be differently arranged so as to give one make and break of con-

tact in the low tension contact breaker every time a cylinder had to be fired.

In addition to distributing the high tension current from the coil, this device is also used to distribute the high tension current from a trembler coil where an accumulator and coil ignition is used in conjunction with the high tension ignition, and for this purpose a wiper T (Fig. 30) is arranged in the face of the half-speed gear wheel E, which also makes contact with the four segments, and distributes the high tension current from the accumulator ignition system. This is accomplished as shown in Fig. 32. Here we have the insulated distributer disk Q with four distributing segments R1,

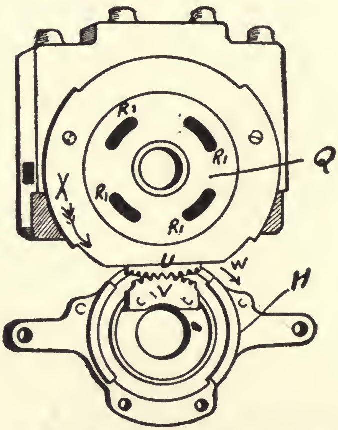


FIG. 32.—THE TIMING ARRANGEMENT OF THE EISEMANN MAGNETO.

R1, R1, R1, but we are now looking at the back of the revolving disk. The wiper T in the wheel E (Fig. 30) as it revolves presses against the back of the distributer disk and makes contact alternately with the four segments. All the four segments are connected to a terminal Y1 (Fig. 29), and this terminal is connected to the primary winding of an independent trembler coil provided with current from an accumulator. It will be seen that current from the accumulator will flow through the primary winding of the coil and pass

along through Y1 to the four segments R1, R1, R1, R1, and every time the wiper in the wheel E comes round and makes contact with any one of these segments the current will flow to ground through the mechanism of the magneto itself.

This, of course, is an entirely distinctive function in the magneto, adopted especially to allow of its being used as a part of a dual ignition system, so that the distributer on one side acts as a high tension distributer and on the other side as a low tension wipe contact maker. The high tension distributer is used for both systems to distribute the high tension current to the plugs, the current being led either from the trembler coil or from the plain coil as may be determined by the position of a two-way switch. This switch is also arranged to put the magneto out of operation when the accumulator ignition is being used; that is to say, it short circuits the low tension current of the magneto to ground all the time, with the result that no inductive effect is taking place in the coil (for it must be remembered that it is only when the current is broken in the primary that the inductive effect takes place in the secondary).

One other feature of the arrangement remains to be described. It becomes necessary in the case of high tension ignition that the time at which the spark shall take place can be varied within certain limits relatively to the position of the piston in the cylinder. When the engine is running slow the time of breaking contact should be retarded, while when it is running fast it should be advanced. The reason of this is that the lag set up in the coil, due to the appreciable time which it takes the low tension current to energize the secondary winding, would cause the engine to fire too late if it were running fast. The time interval as regards the lag in the coil is constant, but the time interval between the piston assuming a position ready for firing at the top of the cylinder and having advanced a little way down the cylinder is inconstant and varies according to the speed.

In the Eisemann ignition appliance, for example, there are three ways of altering the time at which contact shall be

broken by the armature spindle, relatively to the engine, and these are fitted to different types of these machines which it is unnecessary to differentiate between here. In the first case the shaft which drives the armature spindle is connected to the driving part, that is the part which the engine drives in the manner shown in Fig. 33. This plan is not adopted on the particular type we have been describing, but in another type. Here B is the shaft driving the armature A; S is the wheel geared to the engine and runs always at a speed varying with the varying speed of the engine; this wheel is mounted on a sleeve B2, and this sleeve has in it a straight

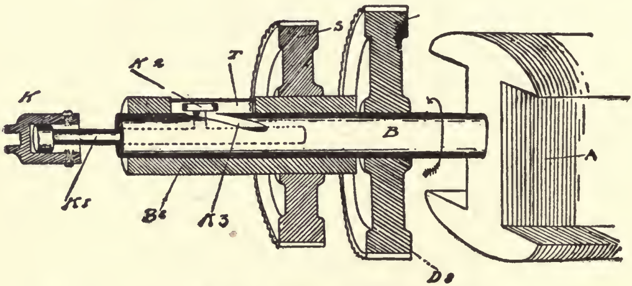


FIG. 33.—HIGH TENSION EISEMANN—THE TIMING SYSTEM.

slot T parallel with its axis. The spindle B similarly has in it a helical slot K3, and through this slot protrudes a pin K2, which can move helically in the helical slot and laterally in the parallel slot. The pin K2 is rigidly fixed in a sliding bar K1, which can slide in a hole in the end of the armature shaft B, and can be pulled in and out of this hole by a swivel K attached to a convenient lever on the car. It will be seen that by pulling out or pushing in the rod K1 the wheel S will be caused to rotate slightly on the armature spindle B, thus the position of B relatively to S can be varied within the limits of the angular movement of K2 in the helical slot K3. If the shaft is rotating, in the direction of the arrow, pushing in the rod K1 will advance the ignition, while drawing it out will retard it. In this diagram D8 is the wheel which drives the distributer shaft, which is somewhat differ-

ently arranged from the model which we have been describing and is driven from the rear instead of from the front. It is obvious, of course, that both the low tension contact breaker and the high tension distributer should be retarded equally and simultaneously. In the case we have described, this is done in a very simple manner.

Now, as regards the later type of Eisemann magneto, the advance and retard is shown in Fig. 32. The plate H which carries the contact breaker is capable of a slight oscillating movement around the armature shaft bearing in either direction as shown by the arrows. It will be seen that at U there is a segment of a toothed circle engaging with the segment of another toothed circle at V. It is obvious, of course, that the armature shaft is revolving in the opposite direction to the shaft of the high tension distributer; therefore, in order to advance them both together they must be oscillated in opposite directions. This toothed segment U forms part of the distributer disk Q, in which are recessed the insulated segments R1, R1, R1, R1. By slightly rotating H in the direction of the arrow W the insulated disk of the distributer Q will be partially rotated in the direction of the arrow X. Thus both will be equally advanced or retarded relatively to the position of the cam on the armature shaft. Although this will advance and retard the ignition relatively to the engine position, it will not have advanced or retarded the armature relatively to the engine position, so that sometimes the break in the low tension circuit will take place earlier and sometimes later than the ideal position in which the best inductive effect is taking place in the winding of the primary coil. The high tension wires from the high tension distributer are taken from the terminals Y, Y, Y, Y (Fig. 29), these being separately connected to the insulated segments.

There is still another way by which the advancing and retarding of the magneto relatively to the engine can be accomplished, and that is by bodily rocking the magneto magnets and pole pieces themselves around the armature. This method, and the method which we first described, with

the helical slot, are the correct ones, because not only is the contact breaking and the distributing advanced or retarded relatively to the engine, but so also is the actual position of the armature, with the result that contact is always broken at the best position of the latter, however advanced or retarded the ignition may be.

We may now deal with the wiring of this system, which is shown in Fig. 34. Here on the left we see the magneto, and on the right the coil box containing the two coils, one coil being that used in the magneto and having no trembler,

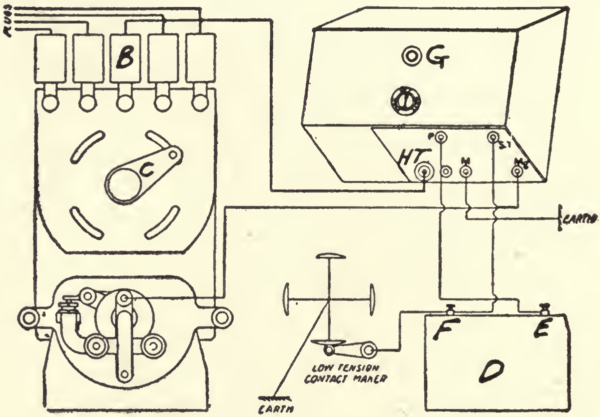


FIG. 34.—DIAGRAMMATIC VIEW OF THE WIRING OF THE EISEMANN MAGNETO IGNITION.

the other being an ordinary coil with a trembler for use with the storage battery.

Let us take first the winding of the magneto. From the terminal on the magneto contact breaker the current is taken by the wire indicated to the terminal M2 on the coil. It flows through the primary winding of the coil, and is taken out at M to ground which completes the low tension (earth) circuit of the magneto. The high tension current leaves the coil at HT and goes to the terminal B on the magneto, this being the terminal which conducts the current to the central wiper C of the distributer, from which it passes alternately from one of its terminals E to the terminal P on the trembler

and so to the plugs. This is the complete circuit, both high and low tension, for the magneto ignition.

The accumulator or battery is shown at D, and a wire is led from one of its terminals E to the terminal P on the trembler coil. It thus passes around the primary winding of the coil, and is taken to ground from terminal M, the ground terminal M being common to both coils, as also is the high tension terminal HT. From the other terminal F of the accumulator the current is led to the low tension contact maker. This device is, for the sake of clearness, shown separately in this diagram, but it will be understood that it is the device which we have illustrated as forming part of the high tension distributer on the magneto. As the segments alternately come into contact with the contact maker, they ground the current as indicated; it will thus be seen that the current has a complete circuit starting at ground, through the coil to the accumulator, to the low tension contact maker, and from that again to ground. The high tension current being induced in the second coil is conducted by the common high tension terminal HT to terminal B on the high tension distributer, and is distributed as before to each plug in turn. In this diagram it will be noticed that there is one wire which we have not mentioned, and it would look as though this wire would make a complete circuit between the coil and the accumulator without the need of the high tension contact maker. This wire runs from F to ST, but its only object is to enable the driver to pass a spark through the plugs whatever the position of the low tension contact maker. This is done by means of a small push button switch G on the coil. This switch puts ST into communication with the primary winding of the coil, so that there will then be a complete circuit from E to terminal P on the coil, out from the coil, through the switch G, and back through ST to terminal F. The effect of this is that as soon as the switch C is pushed and released suddenly, a current is sent through the primary winding of the trembler coil, with the result that that cylinder is fired which happens to be in the circuit through the high tension distributer—

an arrangement which allows, when the engine is warm, of starting it from the switch without having to rotate the crankshaft.

The Simms Magneto System—In this the magneto performs the whole of the functions relating to the ignition, and the apparatus for doing this is contained in one complete machine. The low tension current is generated in the armature, and its circuit is broken at the contact breaker. This induces the high tension current in the secondary winding of the arma-

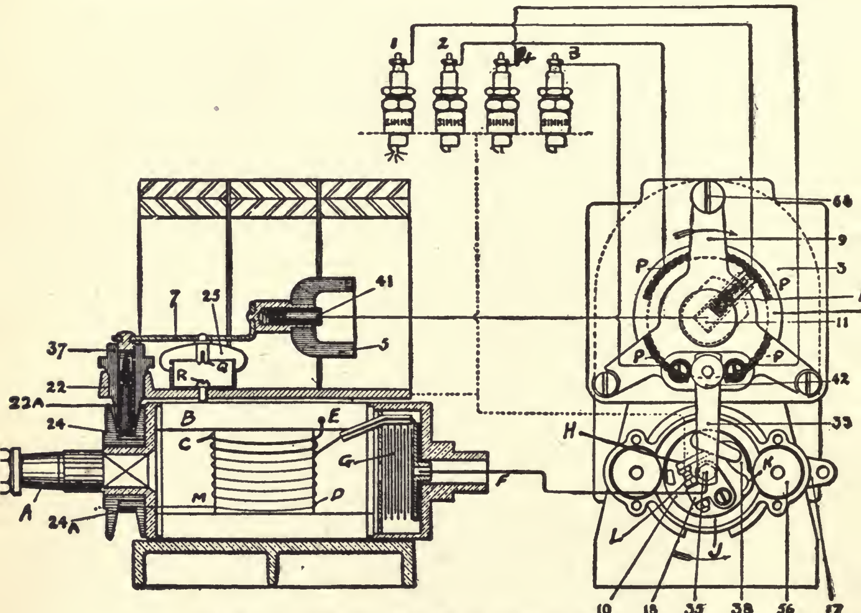


FIG. 35.—THE SIMMS HIGH TENSION MAGNETO.

ture, and this is distributed by a distributer, all four appliances being arranged in the one machine. This is a type specially made for firing four-cylindered motors, and is a recent type of the Simms magneto. In Fig. 35 we have diagrammatic views of the end of the machine with the covers removed, and also a cross-section of the machine. A is the armature spindle, and B is the armature with a winding around it of thick insulated wire at C, and a secondary wind-

ing of thin insulated winding of a great number of turns at D. In our diagram these windings are shown alongside each other and without many turns; this is for the purpose of simplicity in following out the arrangement of the winding rather than actually indicating how it is put on. As a matter of fact, the thick insulated wire is wound round the armature for several rows, and the correct length of thin insulated wire is wound round outside this. The thick insulated wire C forms the primary winding, and in it, by the rotation of the armature (as we have already described) within the pole pieces or fields, is induced the primary current for the coil. This primary current is grounded directly to the metal of the armature at E, its other end being carried out, as shown, to the end of the armature, where it emerges at F. In a shunt between C and F on this primary circuit is situated the condenser G, which is contained in one end of the rotating armature. The diagram on the right-hand side gives the end view of the appliance, and shows that this wire is led to a contact breaker situated at the end of the magneto machine. This contact breaker is shown at 10, and rotates with the armature. In rotating, a pivoted L-shaped lever 38 is forced by a spring up against an outside fixed ring J. The end K of the lever, as it rotates, comes in contact with two rollers, one on each side of the contact breaker, one of these rollers being marked 56. It will be seen that as it strikes these rollers its far end H will be lifted. H has at its end a platinum point which is normally in contact with another platinum point at L on a piece 18 (insulated from the magneto), so that every time it strikes one of the rollers during its rotation it will suddenly break contact between the points at L, the points being kept normally in contact by means of a spring. The low tension current which runs through the wire F is carried to the part 18 of the contact maker, which is insulated, and when contact is made across the points at L the current flows to ground through the lever 38. The make-and-break of contact here occurs twice during each revolution. It will be seen, therefore, that the low tension

current has a complete metallic circuit every time contact is made across the points L, and, when interrupted, induces the high tension current in the secondary winding.

The condenser, which forms part of practically every magneto machine of the high tension type in which a separate coil is in use, is, as we have seen, formed on a shunt on the low tension circuit. The object of the condenser we have already described when setting forth the principle of the Lodge ignition. The primary winding being now quite clear, it is necessary to consider what happens in the high tension circuit, which is induced each time the contact is broken in the low tension circuit, that is, twice during each revolution, it being understood that contact is broken when the armature is in a position in which its edge has left the edge of the field piece by about 1.5 mm.

To follow this circuit we shall have to refer now again to the diagram on the left in Fig. 35. It will be seen that on the armature there is a kind of pulley 24. This pulley is of insulated material, but it carries in the bottom of its groove a metal ring 24A. If reference is now made to the secondary winding D (shown by the fine lines), it will be seen that the wire is led out at M through to this insulated ring in the pulley 24. The other end of the secondary winding is grounded, as in the case of the low tension winding, to the armature itself. Now, at 22 is seen a carbon holder. This carbon holder is of insulated material, and inside it slides a carbon pencil 22A. This pencil is pushed down on to the insulated ring 24A by a spring 37. It is this carbon brush or pencil which picks up the high tension current from the revolving armature through the medium of the revolving insulated ring 24A. The high tension current is then led along a conductor bar 7 to an insulated cup holder 5, having inside it another spring-pushed carbon pencil 41. It is by means of this connection that the current is conveyed from the high tension winding in the coil to the distributer, which we shall next describe.

The distributer is seen more clearly in the right hand of the diagram. The line shown leading from the carbon 41

indicates that the piece 11 is in metallic contact with it. This piece 11 is fixed in a revolving insulated holder, which is rotated by means of a gear wheel on the armature shaft, and revolves at a speed relative to it. It also contains a spring-pushed carbon point N. This is pressed up to a ring O, in which are recessed four metallic segments P, P, P, P. Each of these segments is electrically connected by wire to one of the sparking plugs, as shown. It will thus be seen that as the distributer rotates it will distribute the high tension current to each plug in turn.

There are two other parts of the mechanism which it is necessary to explain. We have shown that that part of the contact breaker marked 18 is insulated from the rest of the machine, and that to it is conducted the wire from the low tension winding. There is a metallic cover arranged to cover the contact breaker, and this metallic cover lics in a circular groove in an insulated ring, so that it is not in metallic contact with the magneto. It is pressed down into position by the spring blade 33, which is anchored on an insulated plate and held down by a terminal screw 42. This spring blade performs a double purpose. It holds down the cover of the contact breaker firmly in position to exclude dust, and it makes metallic contact with the insulated part 18, because inside the cover is a spring blade with a little carbon point or brush, which presses on the screw 35 in the insulated piece 18. From the terminal 42 a wire is run to a switch, by means of which the current may be grounded. This switch is generally arranged on the steering wheel or steering column. When the switch is turned so that the wire is put into metallic contact with the car, the low tension winding, it will be seen, is grounded at both ends—at one end to the armature at E, as we have shown, and at the other end to the car, so that the contact breaker becomes inoperative as far as breaking contact, and no inductive effect takes place in the secondary winding. By simply grounding the low tension circuit to this switch, the magneto is put out

of operation and the engine stopped, nor can it be started until again the switch is opened.

On the left diagram in Fig. 35 will be seen on the conductor bar 7 a dome-shaped piece 25. This is of porcelain, and it will be seen that it carries at its center inside two points Q and R. Q is in metallic contact with the conductor bar 7, carrying the high tension current, while R is in contact with the frame of the magneto itself. The object of this is to form a safety gap, for should at any time the high tension circuit be interrupted, as by the falling off of one of the wires from the sparking plug or from its connection with the magneto, the sudden rise of electrical pressure in the secondary winding might cause the insulation of adjacent layers of the winding to be broken through by the current sparking across through the insulation of the adjacent windings of wire. In order to prevent any accident of this sort, this spark gap is put in, and should the secondary current be, as we have mentioned, interrupted and the electrical pressure in the secondary winding rise too high, it will discharge itself across the points Q and R, and so save the insulation of the secondary winding from damage.

In case any misunderstanding should occur in the mind of the reader, it is well to point out that in the left-hand side of the diagram the distributer mechanism, the contact breaker, and end plates which assemble the whole machine together are left out. They are shown, however, separately on the right-hand side.

We can now trace the wiring of the high tension current. Leaving the armature coil at M, it is picked up from the ring 24 by the carbon wiper 22A. It is conducted along the brass conductor bar 7 to the carbon brush 41. It is there picked up by the carbon brush N and distributed to the segment P, which in our illustration happens to be the one which is opposite the distributer. From P the current is led by an insulated wire to sparking plug No. 1. It will be seen that in the position shown the end K of the L-shaped lever of the contact breaker has just commenced to break contact. It is

rotating in the direction of the arrow, and has just commenced to lift by coming in contact with the roller 56. The distributer, which rotates in the opposite direction, has come opposite a segment in circuit with No. 1 plug. The current jumps across the spark gap in the plug and to earth. A similar circuit would be followed if the distributer brush were opposite any other of the four insulated segments in the distributer, but of course they would lead to different plugs. The return ground circuit is shown by the dotted lines. It will be seen that this very ingenious arrangement of the whole mechanism in one unit necessitates only the four well-insulated wires from the magneto to the sparking plugs.

PART II.

ANOTHER VIEW OF IGNITION.

In order that the reader may grasp more thoroughly the prinples that underlie all systems of ignition another view of the subject is given below.

Ignition is one of the most interesting parts of the general subject of gasolene motor mechanism.

If you know nothing of electricity, never mind. No one knows for certain what it is, but it is fairly easy to learn enough of what it does for the present purpose. Although magneto ignition is now the more prominent, it will be convenient to deal with the battery and coil system first.

The object of either apparatus is to obtain a spark in the combustion chamber, and this spark is made to occur between two points set a little distance apart. The space between the two points forms a breach in the electric circuit, and the electricity in jumping the breach causes the desired flame or spark.

Elementary Electricity.

One analogy is extremely useful to remember—electricity and wiring are very like water and piping. Suppose we have a tank of water and a large pipe having both ends connected to the tank. Means are provided for causing the water to circulate slowly through the tank and pipe, as by introducing a pump into the system. We next make a breach in the pipe. What happens? The water simply dribbles down from

the breach, and we are done. We must get enough pressure on the water to make it jump across the gap. Instead of increasing the power of the pump, we will introduce into each of the broken ends of the large pipe a length of small pipe, and direct the free ends of these at each other, leaving a short gap between them as before. The pump insists on the water getting round the system in a certain time, and so it has to pass through the first length of small pipe at very high speed. There is only a small quantity of water in the small pipe, but it is under great pressure. Consequently it squirts out of the end of this small pipe and right across the gap into the end of the other one. By working the pump intermittently we can get intermittent squirts.

The interpretation is as follows: The tank of water corresponds to a collection or battery of cells, from which electricity will flow. The large pipe is the (primary) wire or other conductor through which the electricity flows in full volume, but at a low pressure. The pump, in combination with the small pipes, suggests (rather imperfectly) the induction coil, by which the (primary or low-tension) current of large volume and low pressure provokes in the secondary or high-tension winding a current of small volume and high pressure. The small pipes also correspond to the high-tension wire, and the gap between them is the gap between the points of the sparking plug which is screwed into the combustion space of the motor. The intermittent working is effected by a contact breaker, a device which is introduced into the primary circuit, and allows the electricity to flow for only short periods at regular intervals, as required for the sparking to take place in turn with the other operations of the motor.

The wire is more like the hole in the pipe than like the pipe itself, so the wires that have to carry the electricity away from the battery to the coil, and away from the coil to the sparking plug, must be provided with a covering or insulation to keep the current to its course. Like a schoolboy, the current displays a wonderful avidity for getting home, so the insulation of the return wires is of little, if any, importance;

and, indeed, in practice, the latter wires are largely dispensed with, the metal work of the car being used for most of the return conductor. As to the outgoing wires or "leads," if the insulation is defective in the neighborhood of conducting material, we must expect to lose our electricity—it will "short circuit," that is, take a short cut for home, without doing its work; just as we lose water from a leaky pipe, only more so. A somewhat similar point is that, though electricity, like water, will take the path of least resistance, yet where there are other outlets, some of the current may be expected to flow through them—the whole river does not run out through the main channel of the delta.

Electricity is rather more like gas than water in one quality. Water may be regarded as incompressible, but electricity appears to have a certain amount of elasticity; if it meets with an obstruction to its flow, it will gather or compress, and then, if the obstruction be not too great, will spring past it.

The quantity or volume of electric current is calculated in amperes, and is measured by an instrument called an amperemeter or ammeter. The pressure of the current is reckoned in volts, by a voltmeter. The product of amperes and volts is called watts. For example, 10 amperes $\times$ 5 volts $=50$ watts, or ½ ampere $\times$ 10,000 volts $=5{,}000$ watts.

The Batteries.

The battery may be either of the primary or of the secondary order. But the words "primary" and "secondary" do not here refer to the degree of pressure in the current, so much as to the manner in which the electricity arrives in them. A primary battery usually consists of three or four separate cells, each comprising a zinc element and a carbon element. The zinc is commonly employed to form the casing of the cell itself, while the carbon is in the shape of a bar. The bar is packed round with a depolarizer of oxid of manganese and bits of carbon. The space between the wrapping of depolarizer and the inside of the zinc casing is filled in with a damp paste compounded of plaster of paris and sal ammoniac. The

top of the cell is sealed (except for a vent hole) with pitch, marine glue, or the like. The carbon is the positive pole of the battery, and the zinc is the negative; each is provided with a screw-threaded pillar or other "terminal," and the positive terminal in one cell is coupled up to the negative in the next cell by metal wires or strips. This is called wiring or coupling "in series," and it gives a comparatively high voltage with a comparatively low expenditure of current. If all the positive (carbon) terminals were connected together, and all the negative (zinc) terminals were connected together, the cells would be said to be coupled "in parallel," and the battery would give a great volume of current at a low voltage or pressure.

When the cells are coupled up in series the carbon terminal of the one end cell and the zinc terminal of the other end cell become the positive and negative terminals of the whole battery. If the zincs of the cells form the exteriors thereof, it is necessary to insulate the cells from each other, and this is often accomplished by enveloping each cell in a rubber wrapping, holes being made for the passage of the coupling wires. The cells should be packed firmly in a box, as vibration would rub the insulation through and spoil the battery. The chemical action of the constituents of the cells is converted into electricity of low pressure—only about 1.25 to 1.5 volts per cell; and as over four volts are required, it is necessary to employ three or four cells. Primary batteries are clean to use, and give little trouble, but they cannot be recharged again and again like secondary batteries.

The Accumulator or Storage Battery.

Primary batteries are often called dry batteries, as there is little, if any, free liquid in them; and also to distinguish them from secondary batteries, in which the electrolyte is generally all liquid, though occasionally it is prepared in the state of a jelly.

The secondary battery or accumulator (commonly called a storage battery in automobiling), generally consists of two

cells only, as secondary cells have a higher individual voltage than primary have. The (secondary) cells are generally put up in a single casing, constructed of sheet celluloid, with a central partition. It is essential that this partition be perfectly sealed. In each cell is a series of plates, positive and negative alternately, one more negative plate than positive, and as a rule there are three or five plates in each cell, both the outside ones being negatives.

The plates are made of lead alloy in skeleton or grid form of different patterns, according to the ideas of the manufacturer. The spaces in the plates are pasted in with oxid of lead. When the cells are charged, the paste in the positive plates becomes converted into peroxid of lead, while that in the negative plates becomes pure spongy lead. The cells are filled up above the tops of the plates with an electrolyte, usually consisting of a solution of sulphuric acid. The proper specific gravity of the solution is 1.190 or 1.200, and in preparing it distilled water or rain water should be used—not city, spring, or well water. Further, the acid should be poured slowly into the water, the converse process being dangerous. If the electrolyte is found not to cover the tops of the plates, the loss is probably due to evaporation, and a little distilled water should be added until the plates are submerged to the extent of one-eighth to a quarter of an inch. If the quantity of electrolyte has been reduced by spilling, it should be made up by adding some of the proper solution. Jelly electrolyte has the advantage that it cannot spill, but it is liable to increase the internal resistance of the battery and decrease the capacity.

A secondary or storage battery has no inherent electricity in it, as a primary or dry battery has; it requires to be charged either from other batteries, or from a dynamo, as described elsewhere.

The Conductors.

Having obtained our supply of electricity, we will prepare to make use of it, remembering that the battery is ever on the watch a chance to short circuit, and that this form of

indulgence is very bad for its internal economy, besides being wasteful of current. In choosing the wire for the primary or low-tension current, we must remember that it has to carry a fair volume of electricity, and it must therefore be comparatively thick; it will also have to be bent about a good deal, and will be subject to plenty of vibration, so it should be as flexible as possible. A cable constructed of a large number of fine wires will therefore be better for the purpose than one consisting of only three or four thick wires. It should be of ample length, as it is much more liable to break away from the terminals or connections if stretched tightly between them; any slack can be wound round, say, a cedar pencil, to form it into a spiral. As the current to be conveyed is of small pressure, the insulation, while perfect in itself, need not be very thick. But for the same reason, the connections or joints between the terminals of the battery and the terminals of the wire should be of ample surface and perfectly clean. There are lots of different patterns of terminals on the market, and it is better to use these, though fairly good terminals can be made with the ends of the wire itself. The ends of the wire have to be stripped of the insulation in either case, and if it is decided to solder the wire terminal, use resin for the flux, as the acid generally employed is corrosive.

One end of the wire is secured to the positive terminal (generally colored red) of the battery; the other end is secured to the terminal marked P ("pile"=battery) of the induction coil if of French manufacture, or B (battery) if an American or English one. The different systems of wiring are dealt with later on.

The Induction Coil.

The name induction coil is indicative of the principle on which this apparatus acts. If two wires or other conductors are arranged parallel to one another, and an electric current is passed through one of them, it is found that a current also passes through the other one at the same time if the circuit of the second conductor is completed. There is no analogy to water here, and no explanation, intelligible to nontechnical

minds, has been offered of the phenomenon, so far as we know. The wire through which the current is passed positively is called the primary, and the wire in which the current is induced is called the secondary. It has further been found that, if the primary and secondary wires are different in diameter and length and in number of turns, the induced current will differ in volume and pressure from the primary current.

This useful fact is availed of in coils for motor ignition to secure a current of great pressure or intensity and small volume, from a primary current of low pressure and greater volume, as given off by the battery. For this purpose the primary wire in the coil is made thick and short, while the secondary is thin and long. But the form of the spark bears some proportion to the secondary wire, and as we want a "fat" spark, the secondary wire must not be too attenuated in proportion to the primary. Fortunately, the wires need not be straight; the effect is obtainable even if they be wound into spirals. The effect is considerably augmented if a bar, or, better still, a bundle of wires, of soft iron be introduced as a core to the whole arrangement. Lastly, it is necessary that the different wires, and even the different plies or layers of wire, be insulated from each other.

Hence the coil for motor ignition takes a form as follows: Right in the middle we have a bundle of soft iron wires, Around these is wound a couple of layers of insulated thick primary wire, the ends being connected within the casing to the terminals. The primary wire or coil is then inclosed in a substantial insulator, such as a tube of vulcanite. Next comes a fine high-tension wire. This is not only covered with insulation, but each layer is insulated from the next, though the wire itself is continuous. The ends of the secondary coil are attached to the terminals within the casing; and the coil as a whole receives a liberal coating of paraffin wax insulation. There is also a condenser, which will be referred to presently.

At the moments when the battery current passes and ceases

to pass through the primary coil, high-tension currents are induced in the secondary coil. But before the current can pass from the battery, the primary circuit must be completed, and we will therefore pursue its course from the coil. The wire from the battery being connected to the proper terminal, the next wire is connected to the other end of the primary coil by the other terminal. The remarks made with reference to the battery and coil wire apply to this one also; it may be called the "coil and contact breaker" wire. See illustration further on.

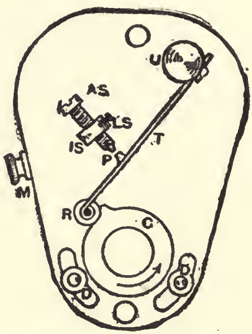
The Contact Breaker.

As the spark in each cylinder is required regularly once in two revolutions of the crankshaft, the current is caused to flow just at these times. The device employed for completing the circuit during the necessary periods, one might well expect to be called a "contact maker," and its full title is doubtless "contact maker and breaker;" but as its function of breaking the circuit happens to be even more important than that of making it, its common name is "contact breaker." It is sometimes called a "commutator," but that application is best reserved for another electrical fitting to be mentioned hereafter. The contact breaker is also adapted to provide means for timing the sparking, that is, causing the flash to occur a little earlier or later in the motor's cycle of operations. But the ordinary actuation of the contact breaker is effected by a rotating part mounted on, or driven by, the half-speed gear of the engine, the same gear as is used for working the exhaust valve.

Supposing for the moment that the contact breaker is in the "make" position, the primary current passes through it, and the primary circuit is completed by a conductor connected to the other terminal of the battery. This conductor may consist entirely of a wire, or it may be partly "earth" or "ground" and partly wire. See paragraph on "Connecting to Earth or Ground" later in this article.

The Make-and-Break Contact Breaker.

There are two principal types of contact breaker, known respectively as the make-and-break, or positive type, and the wipe. In the former, the rotating part consists of a disk C having a projection on it. The wire from the coil is connected to the terminal M which is in metallic contact with the pillar I S. This pillar carries two screws A S and L S the latter serving to prevent A S from turning after it has been adjusted to any desired position. A cover is fitted to the working parts to exclude dust and wet. This cover is pro-



Make-and Break Contact Breaker, Positive Type.

vided with holes for the passage of two screws. Nuts screwed on to the screws hold the cover in position.

The pear-shaped base into which the terminal M, the pillar I S, and the screws are fixed, is made of vulcanite or other insulating material. A spring blade or trembler T is fixed to the pillar U by a screw. On the free end of T is a block or roller R which rubs on the periphery of the disk C. When the projection comes round the blade is lifted by it, and makes contact with the point of the screw A S. This contact completes the primary circuit; the current enters by M, and passes through I S to A S, and from A S it passes to T and C, which are the beginning of "ground." But the contact is of very short duration, as directly the projection on the cam C has passed under the roller or block R the blade T

springs away from the point of the screw A S. As soon as T and A S separate the current is cut off, and it remains cut off until in the course of the cam's rotation, the projection lifts the blade into contact with the screw again. Completing the contact has very much the same effect as turning on water from a faucet, and the trembler spark appears.

Function of the Condenser.

The condenser acts as a buffer or compensating device. It is constructed of a number of sheets of tinfoil, insulated from one another by sheets of paraffined paper. Half the sheets of tinfoil are connected to one wire, and the alternate ones are connected to another. The other ends of the wires are connected indirectly to the screw A S and blade T (or corresponding parts) of the contact breaker. When the primary current strives to continue flowing after the contact is broken, a good deal of it passes into the condenser. And when the contact is again made, the electricity stored in the condenser helps to re-establish the flow quickly. That is not a wholly satisfactory explanation, but it is as far as one can take the matter in an elementary way. These flowing and compressing and bursting actions of the current are performed with extraordinary rapidity.

Advancing and Retarding the Ignition.

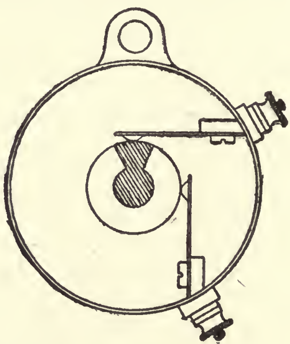
In order to be able to vary the moment of sparking relatively to the operations of the motor, the insulating baseplate can be turned about the axis of the disk. The turning movement is limited by the studs D D (carrying split pins) projecting through the curved slots. The driver effects the movement through a rod connected to the baseplate. The disk C generally rotates contra clockwise, so that if the baseplate is turned to the right or clockwise, the projection will meet the block sooner, and the ignition will be advanced. If the baseplate be moved in the opposite direction the projection will meet the block later, and the ignition will be retarded. The speed of the engine is, under ordinary circumstances, increased or decreased, according as the ignition is advanced

or retarded. The movement of the baseplate does not alter the relative positions of any of the parts mounted upon it, it only alters the position of all of these relatively to the disk C.

Wipe Contact Breakers.

There are several kinds of wipe contact breaker, but they nearly all differ essentially from the make-and-break in that the rotating part has neither notches nor projections. See Contact Breaker on page 88.

In the two-cylinder wipe contact breaker shown in the illustration, it will be observed that there is a sector of metal let into the disk, which in this type of contact breaker is constructed of vulcanized fiber or other insulating material.



Two-Cylinder Wipe Contact Breaker.

The metal sector is in permanent metallic contact with the half-speed shaft, and so with the motor, which is, in turn, connected, generally through part of the car frame, with a short wire leading back to the battery. Bearing on the periphery of the disk are two blocks, carried by spring blades, which are mounted on insulated supports connected with the terminals. There are two blades, because the particular contact breaker illustrated is intended for a two-cylinder motor; they are arranged in positions corresponding to the intervals at which the respective impulses are adapted to take place—either at intervals of 1 and 3, as shown, or of 2 and 2, as the case

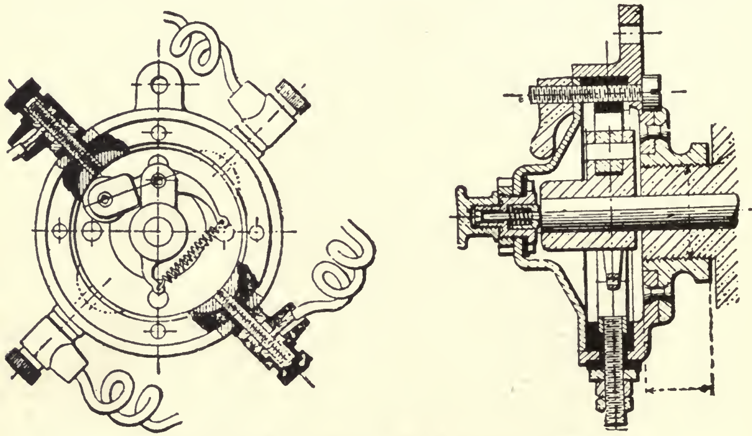
may be. The rocking of the baseplate for timing the ignition affects both blades alike, but each blade is "wired" independently to the coil or coils. Sometimes a separate coil is used for each cylinder, but now it is very usual to employ a single coil in conjunction with a distributing device for the high-tension current. The latter is probably the better arrangement, as tending to evenness of action in the various cylinders. We will describe it more fully in connection with the high-tension circuit.

As the metal sector comes under each blade or "brush" (a dynamo term), the primary current passes through it. Owing to the large arc of the sector, the current flows for a comparatively long time. But as the half-speed shaft turns in the oiled bearings, and oil separates the teeth of the half-speed gear wheels and also the crankshaft from its bearings in the fixed part of the motor, the current has not by any means an ideal path back to the battery; and a wipe contact breaker may often be considerably improved by fitting, first, a spring to bear on a metallic part of the disk or on the end of the half-speed shaft; and second, a wire leading direct from this spring back to the battery.

The Internal Wipe Contact Breaker.

The illustrations in this paragraph represent another pattern of wipe contact breaker. This one is intended for a four-cylinder motor, but it may be modified to suit motors having any other number of cylinders. The construction is the converse of the last. In this case there is only one brush, and it is mounted on, and rotates with, the half-speed shaft, while metal segments, corresponding in number to the cylinders, are carried by the case, which may be moved about its center to regulate the time of firing. The brush is pivoted to an arm fixed to the half-speed shaft, and is furnished with a roller, which runs round the vulcanized fiber lining (with metallic insertions) in the case. A spring couples the other end of the brush to a second arm on the half-speed shaft, and forces the roller into close contact with its path. The metal

segments are in one with terminals projecting through the rim of the case, and each terminal has its own low-tension wire connection. The primary circuits are completed in turn as the brush runs over each metal segment; but here again



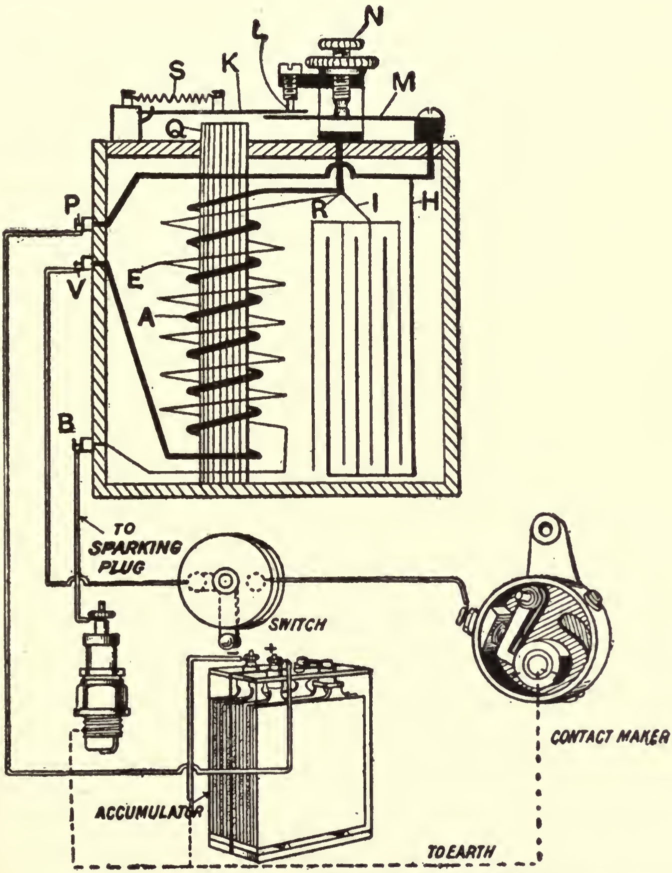
Four-Cylinder Internal Wipe Contact Breaker.

there are a number of films of oil to be overcome before "ground" is properly reached, and the spring contact pressing on the end of the half-speed shaft forms a useful addition.

Trembler Coil Theory.

With a trembler coil an extremely rapid make-and-break device is employed on the coil itself, and is adapted to operate while the wipe contact breaker is in the make position, i. e., while the brush is moving over the metal segment, or vice versa, as the case may be. With a make-and-break contact breaker, the trembler on the coil would vibrate during the time the platinum points of the screw and blade remained in contact. The trembler movements are constructed in different ways, each maker striving to get the fastest action, but the principle is the same in all. A light metal blade K, resilient either in itself or by reason of a separate spring, S, is held by one end on the coil, and frequently carries an iron plate or armature in line with the core of soft iron wire. This

blade, or one (M) which it overlaps, carries a platinum point opposite the platinum-pointed end of an adjustable screw N.



ELECTRIC IGNITION SYSTEM WITH TREMBLER COIL.

A, Primary wire coil.
B, Secondary wire terminal.
B, Secondary wire coil
H I. Condenser leads from blade M and screw N
K, Armature blade.
L, Adjustable stop.
M, Trembler blade with platinum point.
N. Platinum pointed screw.
P, Battery terminal of primary wire.
Q. Soft iron wire core.
R Common connection of primary and secondary winding and condenser
S, Trembler blade spring.
V, Contact breaker terminal of primary wire.

The device, as a whole, is introduced into the primary circuit, the wires being indirectly connected to the parts carrying the two platinum points.

Normally the platinum points are held in contact by the pressure of the spring, so the path is complete, ready for the passage of the current. Hence, when the circuit is "made" by the contact breaker, the current is admitted to the primary winding A of the coil. The current has the effect of "exciting" the soft iron core Q, that is, causes it to act as a magnet which promptly attracts the plate or armature, bending down the blade which carries it. But the necessary consequence of bending down the blade is to separate the platinum points, and so break the circuit. On the current ceasing, the core loses its magnetism and releases the armature, with the result that the blade springs up again and re-establishes the contact between the platinums. This remakes the circuit, the core is remagnetized, the plate attracted, and contact again broken. And so on, again and again, at speeds that almost defy calculation.

Of course, the block and segment of the contact breaker do not continue in contact for more than a small fraction of a second on each occasion, but this is long enough for numerous inductions of high-tension current, and the flashing of a stream of sparks, the individuals of which follow each other far too quickly to be distinguished by the human eye. This kind of coil has two incidental advantages arising from the buzzing sound set up by the vibration of the trembler. First, the emission of the sound is evidence of the satisfactory condition of the ignition system to a large extent; and second, it serves as a warning to switch off the current before leaving the car, if it happens to stop while the contact breaker is "on the make."

The High Tension Circuit.

So much for the primary or low-tension circuit. The secondary or high-tension circuit now remains to be disposed of. We have seen how the high-tension current is induced in the fine secondary winding of the coil. The induction coil really comprises two coils—the primary and the secondary; and each of these is often referred to as a winding, primary or secondary, or high or low-tension respectively, as the case

may be. One point may be noticed at once— while the primary circuit is sometimes furnished with a complete return wire, the secondary circuit is practically always arranged with an "earth" or ground return. There are good reasons for this. In the first place the sparking plug can be made quite a simple affair if the return is by ground. Secondly, as the plug is tightly secured in a stationary part of the motor, the "earth" affords a comparatively good path for the current. And thirdly, the powerful nature of the high-tension current enables it to overcome any little obstacles to its flow that it may encounter. But while the high pressure of the secondary current is a good reason for grounding the return, it is an equally good reason for very carefully insulating the wire conducting the current from the coil to the sparking plug.

As compared with the low-tension wire for the primary circuit, the high-tension wire should have a very much thicker envelope of insulation, and even then the wire should be kept away from metal parts as much as possible. The coil should be arranged as near as may be to the sparking plugs, so that the length of high-tension wire may be reduced to a minimum. The actual wire should be of fine strands, to insure durability, but there need not be as many strands in this wire as in the low-tension, as the volume of current flowing through it is so much less. The high-tension wire is attached to the terminal B ("bougie," literally candle) on a French coil, or S P (sparking plug) on an American or English one. The return circuit often enters the coil by the same terminal as the low-tension return, the one terminal serving for both. The high-tension wire should be only a little longer than necessary; partly because the thick insulation makes it too stiff for any excess to be wound into neat spirals, and partly because the longer it is the more chance there is of its finding opportunities to leak.

High Tension Distributers.

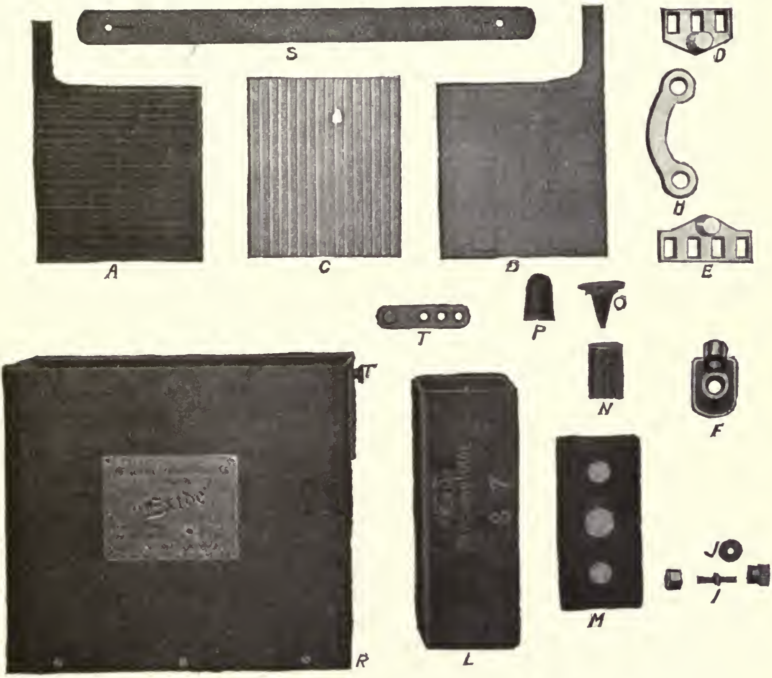
If the engine has only one cylinder, there will be only one high-tension wire; but if there are two or more cylinders,

there will be a wire for each, and there may be a coil for each. In the latter case there will be independent primary wires from the contact breaker to the respective coils, and independent high-tension wires from the respective coils to the corresponding sparking plugs. But, as stated, it is common practice nowadays to employ a single coil for all the cylinders, and to direct the high-tension current to each plug in turn. For this purpose a distributer is employed. In appearance, and to a certain extent in action, the distributer resembles a contact breaker. A single high-tension wire leads from the coil to a terminal which is in metallic contact with a rotating arm. As the arm rotates it communicates the current, in turn, to each of a number of metal blocks, which are connected up to the respective sparking plugs by separate lengths of high-tension wire. The arm is rotated by the motor, and, of course, at such a rate that the high tension current is transmitted to each plug at the correct period in the cycle of operations.

The high-tension wires should be carried in a vulcanite or fiber tube extending along the top of the motor. Opposite each cylinder a hole is made in the tube, and the proper wire led therethrough to its plug. This arrangement prevents both entanglement of the wires and loss of current.

The Sparking Plug.

The sparking plug is designed with the object of providing within the combustion chamber of the motor, a gap in the secondary or high-tension electrical circuit, so that the current, in jumping the gap, may cause a spark or flame that will ignite the charge of gas and impart an impulse to the piston and rotation to the crank shaft. The gap, which should measure about one-thirty-second of an inch, is provided between two points, which are best made of platinum to stand the heat. One point is formed on one end of an insulated pin or thin rod. The other point is formed on a short wire secured to the metal body A of the plug. The body is screwed into the wall of the combustion chamber of the motor, and

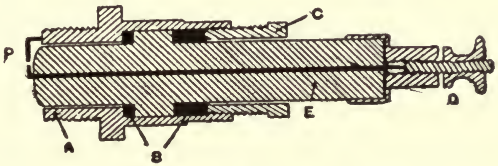


The 1909 Model "Exide" Sparking Battery in Detail.
(The Electric Storage Battery Co., Philadelphia.)

A—Positive Plate
B—Negative Plate
C—Wood Separator
D—Positive Strap
E—Negative Strap
F—Terminal Lug
H—Side-by-Side Connector
I—Terminal Bolt Connector, Stud, Thumb Nut and Hexagon Nut
J—Copper Washer for Bolt Connector
L—Hard Rubber Jar
M—Hard Rubber Cover
N—Hard Rubber Cylinder Vent
O—Vent Plug for Cylinder Vent
P—Soft Rubber Cap
R—Wood Case
S—Strap Handle
T—Fitting for Strap Handle

the second point is thus "grounded" to the secondary winding of the induction coil, one end of this winding being itself grounded, as already mentioned. Sometimes disks or blocks of various shapes are employed instead of wire points, and plugs thus constructed may spark at more than one place.

Porcelain is the material generally employed for insulating the pin in the plug, though mica and other materials are sometimes used. The pin is secured in the center of the insulation E, and projects from it at each end. The outer projecting end is fixed to a terminal D for connecting up the high-tension wire, and it is a convenience, especially in a motor having several cylinders, if the connection can be made and unmade instantaneously. The body of the plug



Section of Sparking Plug.

A, metal body with screw thread. B, packing. C, hollow screw. D, terminal for high-tension wire. E, insulation. P, points.

is provided with an external screw-thread and with flats, whereby it may be screwed into the head of the motor. It is also screw-threaded internally to receive a hollow screw C. The insulation E is formed with a collar or swelling, which rests on a shoulder in the lower part of the body, and the hollow screw is screwed down on the top of it so as to hold it in place. Asbestos packing B is introduced above and below the collar to insure a gas-tight joint, and to prevent the pressure of the metal parts crushing the porcelain. A washer of asbestos and copper should be used in securing the plug in the motor, to insure close-fitting and prevent leakage of compression.

Many plugs are made with the ends of both wires bent to form the gap, but as the porcelain will sometimes slip round a little when the terminal is being tightened up, it is better

for the central wire to be left straight, and only the short one bent; then the turning of the central wire will not disturb the width of the gap so much. Of course, if the gap is too wide, the current will not jump it, and there will be no spark and no impulse. Plugs vary greatly in price, and individual cheap ones will sometimes give better results than others at five times the price. Some are specially constructed to allow for easy refitting of the porcelains in case of fracture; and in the case of the best, and therefore somewhat expensive plugs, this is an advantage.

The External Spark Gap or Intensifier.

This completes the apparatus for inducing the electric current to jump the gap in the cylinder, and fire the charge in doing so. Sometimes, however, through mismanagement of the mixture or the lubrication, or both, the inner end of the sparking plug becomes fouled with carbon; and this being a conductor of electricity, the current will prefer taking a course through the carbon deposit to jumping the gap; or, if the battery is running low, and the points of the plug are too far apart, the current may refuse the leap. Under these circumstances an external spark gap or "intensifier" is found useful. It is frequently provided at the sparking plug terminal, and consists of two metal points mounted on insulating material, and adjusted to about a millimeter (1-25.4 in.) apart; or, if a distributer is used, the rotating arm may be made just too short to reach the metal blocks. The effect is the same in either case. The current is momentarily obstructed by the outside gap, but when it bursts across it the impetus enables it to jump the inside gap also—"outside" and "inside" having reference to the cylinder. The passage of the outside gap is accompanied by a spark, so the device is useful as a visible indication of the state of the ignition. As cases have occurred of the outside spark firing stray gas, it is better to use a pattern in which the gap is inclosed in a glass tube.

Wiring.

The wiring or system of coupling up the various terminals, in the ignition system is of vital importance, as, unless correctly done, no effective sparking will result, and serious damage may be done to the apparatus. Every car should be accompanied by a book of directions containing an easily-understood diagram of the wiring. But this should be backed up by the driver's own knowledge of the subject, and the following hints and illustrations will enable him to deal with most of the cases he is likely to come across.

As to the battery—the positive pole is generally colored red, or it may be marked with a plus or "positive" sign +; it forms the terminal of the positive plates, which are of a chocolate color when the battery is charged. The reddish color plates have the red colored terminal. This positive terminal is generally coupled to the coil.

The negative pole of the battery is generally colored black, or it may be marked with a minus or "negative" sign —; it forms the terminal of the negative plates, which are of a grayish color, and two of which form the outside plates of each cell. This negative terminal is generally wired to the contact breaker, either directly or via "ground."

The Electric Switch.

An electric switch is familiar to everyone in these days. It comprises a spring-controlled handle, the movements of which open and close a gap between two metal fittings introduced into the circuit, so that the current is cut off or allowed to flow, as required. Some switches are made with a handle that can be detached when leaving the car, thus protecting it to a certain extent against meddlers.

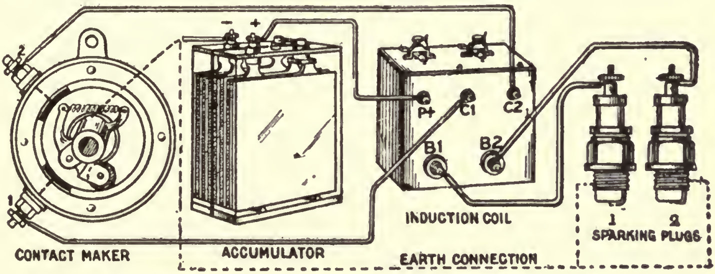
Many motor switches are made with two "on" positions and one "off." These are fitted when the ignition system includes—as it should—two batteries. Batteries being still somewhat erratic in their behavior, it is very desirable to have one in reserve; and it is a further convenience to have this wired up in such a way that the movement of the switch from one

"on" position to the other will enable it to be brought into action should the other battery for any cause cease firing. The two accumulators should be coupled "in parallel" that is, the two positive terminals should be coupled together, and the two negative terminals should be coupled together. The two-way switch should be introduced into one (either) of these couplings, and the switch and the remaining coupling should be connected by single wires to the coil and to the contact breaker (or to ground) or vice versa, as the case may be. Then, though both accumulators will be directly connected either to the coil or to the contact breaker the primary circuit will only be completed through one accumulator at a time, according to which side the switch handle is moved over to. When the handle is in the middle position the switch will cut out both accumulators. Instead of a coupling and single wire, it is often more convenient to run two separate wires from the two like terminals of the accumulators to the single corresponding terminal of the coil or contact breaker (or ground). Or one may run one wire from this single terminal (or ground) to the terminal of one accumulator and a short wire thence to the similar terminal of the other accumulator. The switch wiring must remain as before.

Connecting to "Earth" or "Ground."

As there are two windings (primary and secondary) in the coil, one may naturally expect to find four terminals on the casing, one for each end of each winding. And sometimes this is the case: the two primary terminals being for connection to the battery and contact breaker respectively, and the two secondary terminals being for the sparking plug wire and "earth" return respectively. More often, however, if a coil has four terminals, the fourth is intended to be connected to earth instead of to the contact breaker, which is then made with only the one terminal. It is now usual to provide the coil with only three external terminals, the ground end of the secondary winding being connected, inside the casing, to the contact breaker terminal of the primary winding.

With this construction, at the moment of making contact, both the primary and secondary currents pass through the coil-contact-breaker wire, the primary current being grounded only between the battery and the contact breaker on the motor. The same idea is carried out further where two or more coils are boxed up together in the ignition system of a motor having two or more cylinders. Here, one end of each primary winding is taken to the inner end of a single terminal P+, the exposed end of which is coupled up to the battery; the other ends of the primary winding being provided with separate terminals, which are



System of Wiring with Five-terminal, Double Coil, Wipe Contact Breaker, Earth Returns, and Two Sparking Plugs.

wired to the corresponding terminals of the contact breaker (contact maker). And the earth ends of the secondary windings may also be taken to a single terminal, while the other ends are connected to separate terminals for the respective sparking plugs.

Identifying Connections.

In the ignition systems of motors having two or more cylinders, the sparking plug boss, the contact breaker arm or block (that is, the duplicated, non-rotating element of the contact breaker), the contact breaker terminal on the coil, and the trembler blade, in each set should be marked with a corresponding number. If it has not been done by the maker, you will be wise to do it at your leisure as soon as possible, as it may save a lot of hunting about and mistaken diagnosis on the road. It is also a convenience to use wiring differing in

appearance, by color or otherwise, for the different sections, so that each wire can be identified at different points in its length with certainty and dispatch.

MAGNETO IGNITION.

The great objection to the use of batteries, whether wet or dry, is that the supply of electricity is not permanent—the former kind requires recharging from time to time, the latter has not even a renewable existence. One looks, therefore, for a source of electricity that will be replenished "while you go on" instead of "while you wait." And it is found in the magneto system, by which a dynamo driven by the engine generates electricity at a very small expenditure of power. See Magneto Ignition in a preceding article.

The dynamo consists essentially of a number of steel magnets of inverted U or "horseshoe" shape, arranged so as to form a tunnel or long arch, and an armature wound with insulated copper wire and disposed along the arch so as to lie between the ends or poles of the several magnets. The magnets are excited in the first place by a powerful dynamo, and, as they retain their magnetism for a very long time (sometimes for a number of years), they are called permanent magnets. This term distinguishes them from electromagnets, which are made (as in the case of the core of a trembler coil) of soft iron, and are only excited so long as a current of electricity is passing through wiring coiled round them.

The flat horseshoe magnets sold largely as toys are permanent magnets, and "lines of force" pass across from one pole, called the north or positive, to the other, which is called the south or negative. If a conductor of magnetism (such as iron, but not brass or copper) be introduced between the poles, the lines will tend to deflect and pass straight through the conductor. The armature, being of soft iron, induces the lines of force to pass through it in this way.

The Armature Winding.

Now it was discovered by Faraday that if a circuit of copper wire be caused to cut these lines of magnetic force, an

electric current would be set up in the wire. The current flows in one direction when the wire passes across the lines, say, upward; and it flows in the opposite direction when the wire crosses the lines the other way. This is called an alternating current. In practice, the armature is provided with two, deep, longitudinal grooves, one diametrically opposite the other, so that the transverse section looks something like the letter H. Insulated copper wire is wound on to the armature lengthwise so as to lie in the grooves. The wire used is short and thick or long and thin, according as a low-tension or a high-tension current is required. A spindle is mounted on a brass plate or bridge at each end of the armature, and bearings are provided for the spindles, so that the armature may be rotated by the engine. The armature, with its winding, takes the form of a solid cylinder, and the magnets are fitted with concave pole pieces, almost in contact with which the armature rotates.

Generation of the Current.

When the crossbar of the "core" of the armature lies transversely between the pole pieces, the lines of force run directly through it; and even when the armature has been turned through such an angle that the bar points for the upper part of one pole piece and the lower part of the other, the bulk of the lines will prefer to take the distorted path through the core instead of running directly across from pole to pole through the air. But while the core is turning from this position to about the vertical, the copper wire will cut all the lines of force. The uppermost lines of force starting from the north pole will jump from the lower part of the south pole to the upper part thereof; and the lowermost lines of force entering the south pole will drop from the upper to the lower part of the north pole. As each jump and drop takes place, the lines of force are cut by the coils of the armature winding, and a current is set up therein. By the time the core has reached a vertical position the current will have attained its maximum, and the lines of force divided into two

parts, one passing through the upper segment of the armature and the other through the lower. See illustrations near beginning of first article on Ignition.

Then, as the armature continues its turning movement, the cutting begins again, but the opposite way—both as to the lines and the coil, so that the current continues to flow in the same direction, but with decreasing intensity. When the core has become horizontal again the current has ceased, and on restarting it flows in the opposite direction. When the most lines of force are being cut, that is, about the times the core attains its vertical positions, the currents are at their highest or maximum, and it is at or about one of these two times that the current is generally utilized. When no lines of force are being cut, the voltage falls to zero.

The Armature Spindle.

One can, by suitable adaptations, draw off the electricity generated, either as an alternating or as a continuous current. For an alternating current one end of the armature winding is generally grounded to the body of the armature, and the other is passed axially through one end of the armature spindle which is made hollow for the purpose. This end of the wire is insulated from the spindle, and is either furnished with a metal terminal or is connected to a metallic ring; the terminal or the ring is suitably insulated from "ground." If a terminal is used, the current is received by a spring blade or brush bearing either directly against the end of it or through a carbon rod or other suitable conductor. In the case of a ring commutator, the same rotates co-axially with the armature, and a brush bears upon its periphery. The blade or brush is insulated, and the current is led through it to an insulated wire, which is connected up to the apparatus to be operated. A continuous current is not often used for magneto ignition.

Some motorists couple up a dynamo, driven by the engine, to their accumulator to insure keeping the latter fully charged. But few cars are so equipped as standard pattern; nor is a dynamo ever regularly fitted as a mere substitute for a battery, though such an arrangement might offer certain advantages.

The Bosch Arc Light Armature.

The arc light armature is remarkable, not only for the fact that it is stationary, but also for the method of winding. There are two coils of wire, one short and thick, the other long and thin, as in an induction coil. But instead of the two coils being kept strictly separate, one end of the fine wire is connected to one end of the coarse. The other end of the primary wire, as it may be called, is "grounded" to the core, and the other end of the secondary wire is led centrally down the hollow spindle of the armature. Within this hollow spindle the end of the secondary wire is connected to one arm of a ⊃ piece, the other arm of which carries a carbon brush, which leads the high-tension current to a metallic ring in the disk of the distributer. Notwithstanding that the two coils are directly connected, they have the desired transforming effect, and a current of great intensity is produced in the secondary winding. The return for the high-tension wire, it will be noticed, is right through the primary wire.

Contact Breaker and Distributer.

From the point where the two wires are connected together, an insulated tubular conductor extends through the hollow spindle of the armature, and is coupled up to the stationary portion of a contact breaker. The live end of the high-tension wire and part of one end of the ⊃ piece lie within, and are insulated from, the tubular conductor. To the end of this conductor is clipped an irregularly-shaped bar, which is connected at its other end to a block carrying the stationary part of a make-and-break contact breaker. The moving part of the contact breaker is earthed, and consists of a lever pivoted transversely in the lower end of the timing lever. The upper end of the contact lever carries a platinum tip in line with the similarly-tipped screw forming the stationary contact; the lower end of the contact lever bears upon a disk fixed to the rotating sleeve. In the face of the disk there are four equidistant recesses, leaving four intermediate projections. When a recess comes round opposite the lower end of the con-

tact lever it allows the upper end thereof to move forward (under the action of a spring), and so complete the contact.

A condenser is packed in a casing arranged over the armature and sleeve. The terminals of the condenser are connected to the stationary part of the contact breaker and to earth respectively; so the condenser is practically connected across the points of the contact breaker, as usual.

The distributer disk is mounted upon, and rotates with, one of the sleeve spindles. A brass ring is let into the disk and a segment in connection with the ring extends to the periphery. Four insulated carbon brushes, with suitable terminals, are mounted radially and equidistantly in a casing surrounding the disk, and the high-tension current transmitted to the ring by the brush in the ⊃ piece is distributed to each of the four radial brushes in turn by the brass segment. The terminals of the radial brushes are coupled up to four vertical sockets by suitable leads. These sockets are sunk in the lower part of a vertical insulator plate; the top half of the plate carries four corresponding pins, the lower ends of which fit snugly into the sockets, while the upper ends form terminals for the respective sparking plug wires of a multi-cylinder motor. If the motor has only one or two cylinders, the surplus brushes will not be utilized, and only one or two sparking plug wires will be attached. The plate and its fittings provide a ready means for breaking the electrical connections when required. The sparking plugs may be of the ordinary kind, though the makers of the magneto recommend the use of one known by their name. No contact breaker is required on the camshaft, nor any coil, apart from that of the armature.

Action of the System.

The contact breaker lever and one end of the primary wire being earthed, and the other end of the primary being connected through the conducting tube and the bar with the stationary contact screw, the primary circuit is completed every time the platinum points make contact; and the current, then being generated, takes this course. But as the

recess in the disk passes away, the adjacent projection pushes the lower end of the lever forward and the upper end back, thus breaking contact. The break is timed to occur when the current is at one of its maxima, and while the segment is in contact with one of the radial brushes. The contact breaker points being separated, the high-tension current is forced to traverse the secondary circuit, traveling through the secondary wire, the inner tubular conductor, the ⊃ piece, the lateral carbon brush, the brass ring and segment, one of the radial brushes, the lead, socket and plug appertaining to that brush, and the high-tension cable to the points of the sparking plug, and returning via "earth" and the primary wire to the secondary winding.

Rocking the timing lever causes the lower end of the contact lever to encounter the recesses and projections on the disk sooner or later, as the case may be, and the moment of sparking is changed accordingly. As the axis of the timing lever is in line with the platinum points, the movements of this lever do not displace the relative positions of the contacts. There being no trembler or equivalent device, a single spark only is produced at each plug, but this spark appears to be particularly well adapted to firing the charge, and will fire very weak mixtures.

An Emergency Exit.

If the high-tension current failed to jump the gap at the plug (it should measure exactly .4 mm.), or was otherwise interrupted, as by one of the sparking plug leads being disconnected it might "break down" the insulation, and so spoil the apparatus. To guard against this risk, a spark gap is arranged between the lateral or feeder brush holder and the conductor bar, thus providing an emergency exit for the current. But this is only a temporary relief. If it is desired to run the magneto without using the current generated (as in the case of dual ignition systems), the circuit should be shorted by means of a switch introduced into a wire, one end of which is connected to the terminal on the conductor bar,

while the other end is grounded. By setting the switch so as to connect the parts of the wire, the primary circuit is short-circuited, and all risk of damage removed.

Dual Ignition.

As it is often easier to start up a car on battery and coil ignition than by a magneto, and as with the former system it is frequently possible to restart the car simply by switching on; and, further, with a view to immunity from total failures of the ignition, many users of magneto ignition prefer to employ an accumulator or battery and coil system as well. This means a certain amount of complication, and, in order to reduce it as far as may be, the two systems are often combined to a greater or less extent, and are then referred to as dual ignition. In this, the one set of plugs and the one distributer are used in common for both systems, and a switch is employed, which serves to couple up the battery and coil, while it cuts out the magneto, and vice versa. The switch also serves to short-circuit the primary of the magneto, both when the battery is in use and when both systems are switched off. One might think that, where the magneto was of the low-tension kind, working with a coil, the one coil might be used for both systems, but this is seldom practicable, as the current generated in a magneto primary is generally considerably greater than that generated by a battery.

GENERAL SUMMARY OF IGNITION.

All so-called gasolene motor cars, that is, cars fitted with gas engines of one type or another, are now fitted with some form of electric apparatus to ignite the explosive mixture in the cylinder. No agent has proved itself so generally convenient, reliable and safe as electricity.

Other systems which have been or are being tried are:

(a) Ignition by a very hot tube (made hot by an external flame, generally from a gasolene lamp).

(b) Ignition by a very hot wire (made hot by catalytic action).

(c) Ignition by an injection of very hot jet of air or gas (made hot by compression in a small pump).

(a) Tube Ignition—This has been practically abandoned, chiefly on account of the danger of fire from the flame, the trouble with the lamp going out, and, lastly, the impossibility of advancing or retarding the moment of firing while the car was in motion.

(b) Catalytic Ignition—This has never passed the experimental stage. The heating of the ignition wire depends on the fact that when certain metals such as platinum and palladium are exposed in a spongy or finely divided state to the action of mixed explosive gases such as hydrogen or gaseous hydrocarbons and oxygen, they absorb these gases to a slight extent and in so doing become sufficiently hot to fire such a mixture of gases as occurs in the cylinder of a motor car. Catalytic plugs based on this principle have been used with but moderate success owing to the necessity for electric heating of the wire to start the car, to the necessity for supplemental electric gear to obtain the power of timing the ignition; and to the uncertainty of the action; for example, the heating effect does not take place if the plug should become coated with a layer of soot or lubricating oil.

(c) Hot Air Ignition—This is perhaps the most promising of the experimental systems. The idea worked out by some engineers is to compress very highly a small quantity of air or mixture in a separate pump, driven from the engine, until the air has attained a temperature sufficiently high to ignite the mixture. It is then injected into the cylinder, at this temperature, towards the end of the compression stroke. Timing is effected mechanically.

Electric Ignition Systems.

1. Electric ignition is always effected by passing a small electric current (rendered visible by its effect as a brilliant spark) through the mixture of gases it is desired to fire. Electric ignition devices may be classed in two groups, High Tension and Low Tension, and excellent results can be got from either system.

2. High tension is perhaps the more popular. Current is primarily obtained either from—

(a) Accumulators or so-called storage batteries (generally a battery of two cells).

(b) Dry cells (generally a battery of from four to six cells).

(c) A dynamo machine driven by the engine on the car.

(d) A magneto machine driven by the engine on the car.

The primary current, whether it be derived from a, b, c, or d, must—

(A) Be strictly limited to the primary circuit (that is, it does not go to the engine or spark plug at all).

(B) It must flow round a helical coil which is concealed in the coil box. (See Induction Coil.)

(C) It must be interrupted with great suddenness (or even reversed in some cases) while it is so flowing, by means of some interrupter arrangement usually fitted with platinum contacts.

(D) It must be of sufficient amount, say half an ampere, to thoroughly magnetize the coil.

(E) It must be supplied under a sufficient pressure (four or six volts) and for a sufficient length of time to insure (D) above.

3. The effect of these five things happening at the proper moment is as follows:

(i.) At each sudden interruption above alluded to a secondary current arises. (Notice that the mere steady flow of the primary current has no useful effect.) It must be interrupted in a sudden manner.

(ii.) This secondary current is kept quite distinct from the primary. It is also different from it in every characteristic, and flows round an entirely distinct and separate circuit.

(iii.) The origin or birthplace of the secondary current is in the coil box, not the battery. It is not even in the same helical coil of wire as the primary, but in a secondary coil placed near to it and around it, insulated from it with silk, wax, ebonite, etc.

(iv.) The amount of the secondary current is very minute, say a thousand times less than an ampere.

(v.) The pressure or voltage which forces it round the secondary circuit is, however, very high, say 20,000 volts. Hence the name, High Tension system.

(vi.) The high tension has a strong tendency to break down or pierce by means of a spark the weakest spot of any insulation on the wires of its circuit; for this reason a very thick rubber coat is put over this wire where it is exposed.

(vii.) The above fact is utilized and a weak spot in the insulation is purposely provided at the place where the points of the spark plug are nearest to one another, viz., inside the engine cylinder where the spark is wanted.

From the characteristics of the secondary or high tension current above given, it is clear that if the ebonite, wax, or silk inside the coil box should get cracked, melted, or displaced, or if the rubber on the high tension wire should get abraded or leaky, the spark is liable to occur at the new weak spot instead of in the cylinder. This results in a failure of the ignition, to the great displeasure of the motorist, who must either localize and cure the defect or submit to the annoyance of misfires or even of a total stoppage.

These and many other possible causes of breakdown are well to be borne in mind by the painstaking driver. For Batteries, and their management, or for Induction Coils, the reader is referred to the articles where these devices have been dealt with under their own names.

4. The Circuits—From what has been said above, it is clear that there are two circuits for all high tension systems.

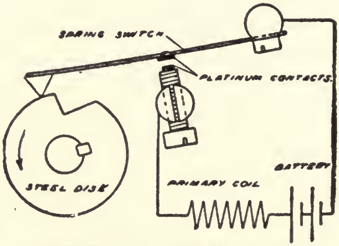
(A) The battery circuit, called primary circuit.

(B) The spark plug circuit, called secondary circuit or high tension circuit.

Unlike our usual ideas of the flow of water which will pass from a tap to a drain when the tap is turned on, electric current will not flow from one point to another unless these two points are in the path of a completely-closed circuit.

If we effectively interrupt the continuity of any closed cir-

cuit, we stop the current in that circuit, no matter at what point the interruption may be made; that is why turning the control switch stops the entire ignition system and therefore the car.



DE DION CAM ACTUATED SPRING SWITCH FOR JUMP SPARK

Details of Primary Circuit in the De Dion System.

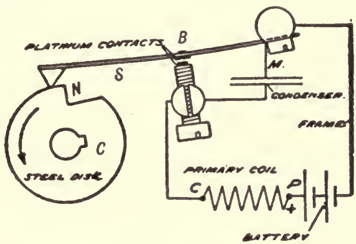
5. In the primary circuit of an ignition system, a man swimming with the electric current inside the copper conductor, would, if he started from the + pole of the battery, follow the wires and pass in turn through—

(a) The + terminal of the battery.
(b) The control switch.
(c) The terminal in the coil marked P or B.
(d) The primary winding on the coil.
(e) The trembler blade.
(f) The platinum tipped screw.
(g) The terminal on coil box marked C.
(h) The commutator brush.
(i) The brass commutator contact piece.
(j) The frame of the car.
(k) From the frame to the ground wire.
(l) To the negative pole of the battery.
(m) Through the battery liquid and through the plates till he returned to
(n) The + pole of the battery.

When swimming in the tortuous wire of the primary winding of the coil, he would notice if he were empowered to see through the silk, ebonite and wax insulation, that he is very near to the secondary winding of the coil, called the high ten-

sion winding, but the primary circuit never comes into contact with it save at one single point, viz., the binding screw C on the coil box.

6. The Rotary Contact Maker or Breaker—If a sequence of sparks were required to continue without any measured interval of time elapsing between them, this device would not be wanted, as the trembler blade is quite sufficient to secure a constant shower of sparks, but in order only to fire the mixture at the right time (namely, when the compression is about complete) the primary current is only allowed to flow at the appropriate moment by the rotary contact maker which



Position and Connections of Condenser When Coil is Not Fitted With a Trembler Spring.

is arranged to be driven by the engine camshaft at half the speed of the engine and is adjusted to make contact only at the precise instant when sparks are wanted. See Timing.

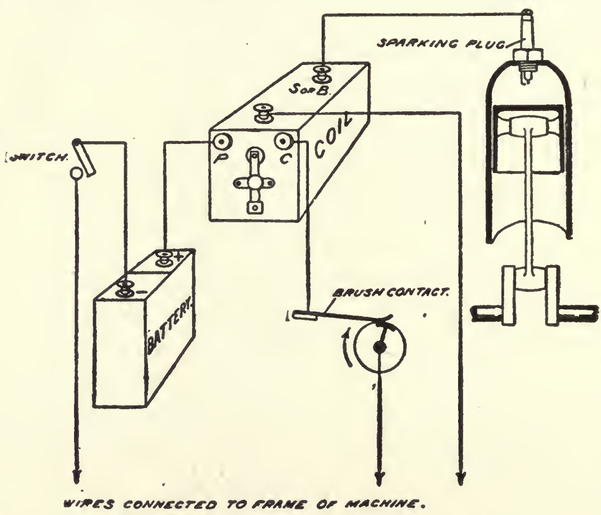
7. The Trembler—As the rotary contact make-and-break closes the primary circuit and then a little later interrupts it, the condition necessary for the induction of a current in the high tension circuit is complied with even without the use of a trembler. The object of the trembler is merely to cause a large number of additional "makes and breaks" of the circuit at a much higher rate of breaking the circuit, that is, with more suddenness than is effected by the slow moving rotary contact maker. So true is it that the trembler is not strictly necessary that many ignition systems dispense with it, but in return those systems have to provide that the rotary contact maker has platinum points and other peculiar features to secure a very much more rapid action than the

slow "wipe" (as it is called) of a brass brush against a brass contact piece. When a trembler is mounted on the coil it is usual to distinguish the coil so equipped by calling it a "trembler coil."

8. The value of a rapid break of the primary circuit is very great in improving the intensity of the spark in the high tension circuit.

9. The High Tension Circuit or "secondary circuit" is extremely simple. The high tension current flows:

(A) Through the high tension winding on the coil, in which it is generated by induction in a spasmodic manner



Complete One-Cylinder Ignition Diagram—Battery and Coil System with Trembler Blade.

every time the primary circuit is (a) closed rapidly; (b) broken rapidly.

(B) It passes through the insulated terminal of the coil.

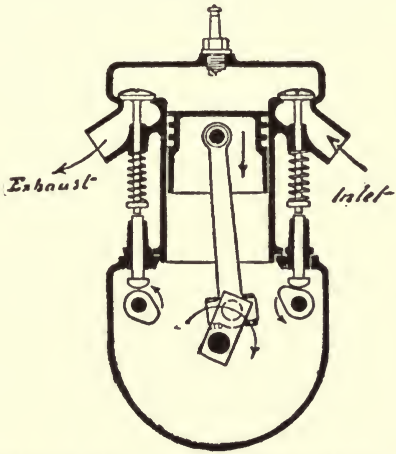
(C) Through the high tension wire, which is covered with an extra thick coating of rubber.

(D) Through the binding screw on the spark plug; down the central stem of the spark plug.

(E) It jumps as a spark across the spark gap.

(F) It flows round the casting which forms the engine cylinder to the car frame and back to the other end of the coil, where usually the secondary winding is connected to the primary winding (making use on its way of the rotary contact-breaker in the primary circuit, which simply acts as a "ground" connection, that is, a connection to the frame of the car).

10. A great deal of the apparent intricacy of the electric gear in a car is due to the fact that the wires are necessarily



Position of Valves, Valve Cams, Piston and Crank When Spark Has Just Occurred.

invisible through a part of their length (when they enter each piece of apparatus).

Thus, although the wiring diagrams may be clear enough, the least departure from the arrangement shown by them is apt to puzzle a beginner. As an exercise he should examine other diagrams and trace in them the primary and secondary circuit lines of travel.

11. Ignition for Several Cylinders—So far a single-cylinder engine ignition has been dealt with for the sake of simplicity. For more cylinders the whole system could be re-duplicated

once for each cylinder with satisfactory results, save that a simpler and cheaper method can be got by using:

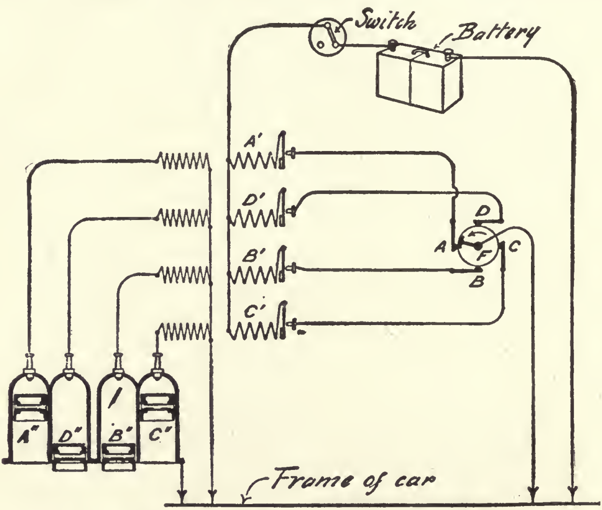
(a) One battery for all the circuits and as many trembler coils as there are cylinders, or, simpler still—

(b) One battery and one trembler coil only for all the cylinders.

Both (a) and (b) are in every-day use.

The cases where a non-trembler coil is used for one or several cylinders are dealt with later in this article.

12. Ignition from One Trembler Coil to Several Cylinders —In this case the electrical connections of the primary cir-



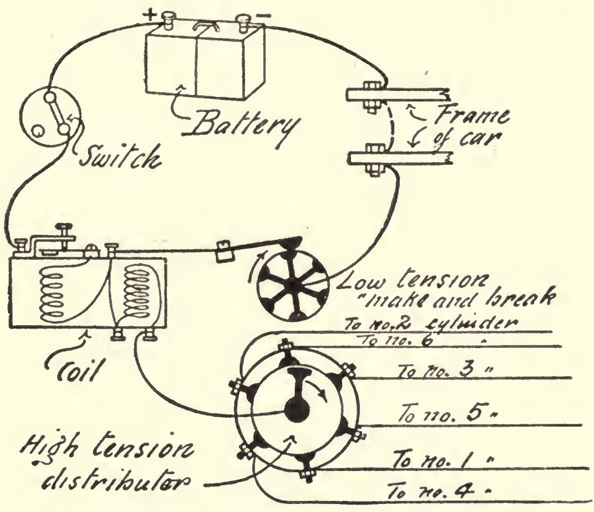
Connections for a Four-Cylinder Ignition, with Four Trembler Coils But Only One Battery.

cuit are substantially the same as when one coil is used to make a spark in one cylinder, save only that instead of there being only one closing of the circuit by the brass brush pressing on a brass segment once for each revolution of the contact maker, a number of contacts are wanted, and therefore a number of segments are introduced, one for each cylinder.

13. The high tension current is directed to whichever

cylinder requires a spark, by a high tension distributer. This consists simply of a carefully insulated central arm, which rotates with the contact maker to which it is mechanically coupled. This arm comes very close to each in turn of high tension terminals arranged in an ebonite supporting ring at approximately the same moment as the brush touches one of the contacts. Obviously if six, four or two cylinders are used, there are only six, four or two high tension terminals and also only four or two contacts in the rotary contact-maker.

14. High Tension Distributer—In all cases where a high tension distributer is used, the leakage of the high tension cur-



Ignition of Six-Cylinder Engine From One Trembler Coil and One Battery.

rent from terminals along the exposed ebonite surfaces must be carefully guarded against by keeping the parts scrupulously dry and clean. If the rotating arm were to make a rubbing contact against the terminals metallic powder would be liable to be spread over the ebonite ring as a thin conducting film, hence it is usual not to allow the arm to touch the

terminals, but merely to come very closely to them. The high tension is sufficient to force the current to jump this small distance on its way to the spark gap. This small "jump" constitutes effectively what has been termed a spark "intensifier."

15. High Tension Ignition by Dynamo—Where it is not easy to get batteries recharged these are sometimes—but rarely—dispensed with by employing a little of the power of the engine to generate on board the car the electricity required as and when it is wanted.

In this case, besides the waste of power, which is comparatively slight, there is also the minor drawback that the engine will not start on merely turning the switch, even though it have four or more cylinders unless a supplementary battery be carried for starting.

The dynamo may be driven from the engine by spur, chain, belt or friction gearing. In the case of one make of dynamo the gear ratio has to be such that the armature will run at about 1,400 revolutions per minute, and an automatic clutch governor is provided which allows the dynamo pulley to slip, and so prevents the speed from exceeding that amount. Another reason for having a battery as well as a dynamo is that, unless the engine can be turned by hand at such a rate that the armature revolves at at least 400 revolutions per minute for a dynamo, or 200 revolutions per minute for a magneto, a separate source of electricity supply has to be used at starting. Such a source may be dry batteries or accumulators, of which alternatives the former is most to be recommended (if used for starting purposes exclusively).

There are two methods of installing the dynamo system:

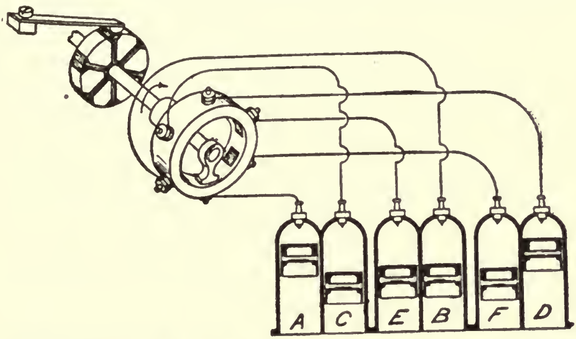
1. To connect the dynamo terminals direct to the ends of the primary winding of the induction coil.

2. To connect the dynamo terminals to a storage battery so that the current from the dynamo is used merely for recharging the battery.

The first method is usually arranged to give about 12 volts to the primary circuit under normal conditions. The elec-

trical connections are exactly the same as if the dynamo were used instead of the accumulators.

The second method has the advantage that the accumulators are kept continually charged, and it also provides a spare source of electricity, for should the accumulators fail, the dynamo may be connected up as above. On the other hand, should a failure of the dynamo be detected, the accumulators are ready charged.



High Tension Connections of a Six-Cylinder Distributer for Ignition From One Trembler Coil.

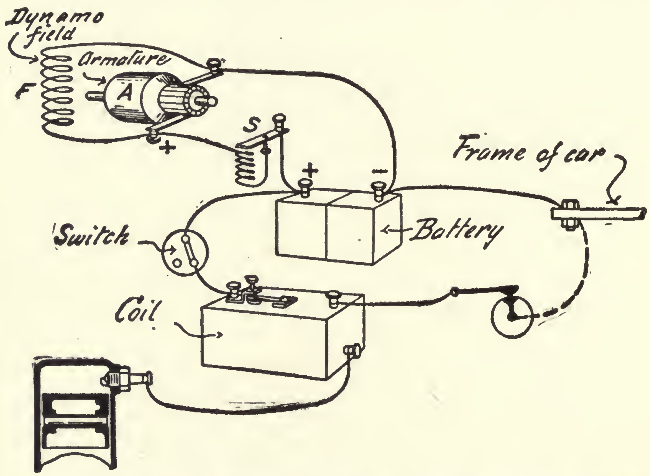
16. High Tension from Magneto Machines.—The term High Tension Magneto Ignition is generally applied to one of several systems in which some special feature is introduced. See Magneto.

The chief reason for the introduction of the magneto system is found in the disadvantages of storage batteries. These may be briefly summarized as follows:

Weight, volume, brittleness of case, overflow and spillage of acid, susceptibility of becoming exhausted without giving warning, low internal resistance, difficulty of identifying the polarity of the terminals, difficulty of knowing whether battery is charged or not, delay of recharging, deterioration by mere waiting—sulphating, buckling of plates by rapid discharge (objections to buckling), difficulty of transport by rail or express, etc., falling out of paste in course of legitimate use as

well as by abuse; unsuitableness of lead to stand vibration, that is, breakage of lugs.

A brief review of the principles underlying this system of ignition may be given. In the first place, it is impracticable to generate electricity at high tension direct from the magneto machine, so that all magneto systems use the magneto to generate low tension current and an induction coil to convert it to high tension. Roughly speaking, the magneto takes the place of the battery or dynamo in the systems previously described, but as the current obtained is of an alternating



Dynamo and Batteries Together in One Ignition System.

character instead of continuous, the rest of the ignition apparatus is modified to suit the new conditions.

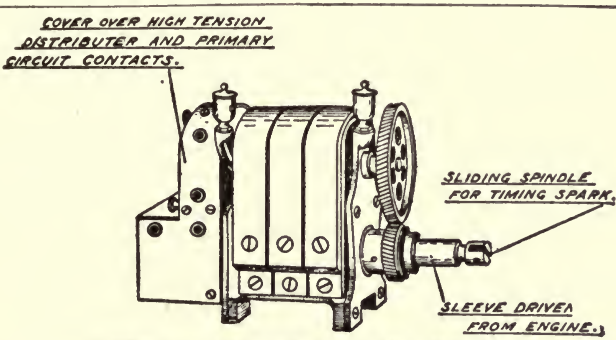
The production of a current by a magneto, and the production of the current in the secondary winding of an induction coil, both depend on the same fundamental phenomenon, namely, that a current is "induced" in a wire or coil of wire which is exposed to the influence of a magnetic field of varying strength.

In magneto machines the magnetic field is provided by steel "permanent" magnets between the poles of which a coil

of wire is placed, and the variation of the magnetic field or "flux" is obtained either by rotating the coil of wire or by moving an iron core in the field.

This coil of wire with its core is called the armature.

In the case of one type of magneto (the Bosch) the "armature" and permanent magnets are stationary, and the variation of flux through the armature coil is caused by revolving or reciprocating a soft iron shield in the space between the armature and the magnets. So far as the resulting electricity is concerned, it does not matter whether there is a revolving armature or a reciprocating or revolving iron shield. The final result is the production of electricity at low tension in the armature windings which form part of the primary cir-

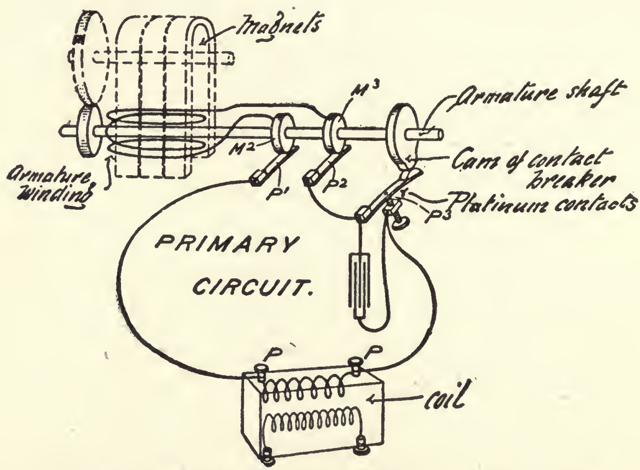


Eisemann Multiple Cylinder Magneto.

cuit, and the problem to be solved by the designer of high tension magneto apparatus is to convert the low tension to high tension and then distribute it to the cylinders, there to generate sparks at exactly the right moments, no matter what the speed of the engine may be. It will be obvious to any one who has read the foregoing matter on ignition that a primary and secondary coil is required, and these may be mounted in a coil box as hitherto, as in the Eisemann, or induction coils may be built up on the armature, using the armature winding as its primary and the armature bobbin as its core, as in the Bosch and others. The next necessary adjunct is a contact breaker in the primary circuit arranged to

open or break the armature circuit with great suddenness when the current is at its maximum value. The third principal part is a high tension distributer whose function it is to distribute the sparks to the cylinders. Lastly, some facility is almost always provided for altering the timing of the ignition at the will of the driver. It is in the finding of means to all these ends that the differences arise between the various systems. See Magneto.

17. Low Tension Ignition.—This system is falling out of use in some cases and being newly adopted in others. Its



Primary Circuit of Magneto System (Eisemann).

advantages are the great amount of heat which can be provided at the spark and the simplicity of the electrical circuit. Its most serious drawback is the introduction of moving parts into the cylinder, which gives it an appearance of complexity. There is further some difficulty in insuring accurate timing in multi-cylinder engines, if the moving parts of the ignition gear do not wear evenly. Nevertheless, more power can probably be got from a given cylinder volume and from a given quantity of gasolene with this form of igniter than any other commercial method.

When a circuit carrying a current is broken a spark occurs at the point of breaking. The intensity of the spark from an accumulator is much greater if the circuit possesses a "self-induction" coil. If the source of current is a magneto, the armature winding is effectively a self-induction coil. No supplementary coil need be used.

A typical Bosch low-tension magneto is geared to the engine so that a soft iron shield oscillates between the fixed armature and the magnet pole pieces. The oscillation of the shield varies the magnetic flux through the armature winding, and so induces an electric current in it.

In the rotary type of this magneto there are four points per revolution of the shield when the induced current is a maximum, and four points when it is zero. To obtain a spark it is, of course, necessary not to break the circuit when the current is zero; the spark will be best if current is broken at or near one of its maxima. This is effected by means of a cam, tappet rod and contacts.

The actual contact is broken between a lever and a stud fixed inside the head of the cylinder, the suddenness of the break being due to the strength of spring and the steepness of the notch on the cam which actuates the tappet rod. Immediately the circuit has been opened it is closed again by the action of a spring.

The electrical connections consist, as far as the user is concerned, of one wire from the magneto to the insulated terminal in the cylinder.

In another system the make-and-break in the cylinder is effected magnetically, so as to dispense with rod and spring. The spark advance is effected by the ingenious method of rocking backward the permanent magnets, and so obtaining the maximum voltage at an earlier moment.

IGNITION FAULTS AND HINTS.

If electrical matters are not your forte, ignition is a likely point of failure; hence the first thing to do when the engine unexpectedly refuses to give the regular beat of its explosion

is to see whether you obtain a spark between the frame of the machine and the insulating cap of each sparking plug when the engine is turned by means of the starting handle through one or two complete revolutions (of course with mixture cut off and compression released where provision for this is made in the machine).

When doing this connect one end of the copper of a thickly insulated wire to the frame of the machine and place the other end very close to the exposed binding screw or brass cap of the spark plug; if you get a good spark you may be almost sure that the ignition is not the cause of the stoppage. If you cannot get a piece of insulated wire, a key or a spanner will do as well, provided you are careful to avoid getting a shock by keeping the metal of the spanner well grounded—that is, in contact with the frame. If you get either a fat spark or a strong shock, the ignition is probably all right. If you greatly dread a shock, undo the high-tension wire, and, holding it by the rubber insulation, try the high-tension spark, which should be about ½ inch long in air and very bright. Special terminals are made for the rapid disconnection of the high-tension wire for this purpose. There are, however, five cases in which you will obtain a spark or a shock, although the ignition is the cause of failure.

The first case is when the battery is practically empty, but has had time to recover in a temporary manner owing to the stoppage of the car. You will probably find that the engine will re-start and only run a little way. The only cure for this is to have a second battery, which should be switched on with a two-way switch.

The second case is when some one of the wires of the system is making a bad connection or is partially broken. In this case the running of the car will shake the broken or loose parts asunder, whereas the stationary car may give you a satisfactory spark. The quickest cure for this in the long run is not to hunt for faults, but to tighten one by one every binding screw and turn the handle again. If this does not cure it, pull out one by one every wire in the car

and replace them with your spare wires. The reason for not hunting out the fault is that the break has probably occurred within the thickness of the insulation itself, and is not discoverable without instruments or, at any rate, a tedious search.

The third case is when the two points of the spark gap within the cylinder are too far apart, or have too much oil, soot or moisture on them to allow a good fat spark to occur within the cylinder. Remember that a spark does not occur with the same ease in the compressed gas of the cylinder as it does in the open air.

Fourth.—It is possible that the porcelain or mica insulator of the sparking plug is cracked or allows the current to flow through it. This is cured at once by inserting a spare plug.

Fifth.—If the high-pressure spark appears to be thin and weedy, so that you suspect it of not being hot enough to ignite the gas within the cylinder when under compression, it is probable that one of five things is the cause—

1. The battery has run down.
2. The trembler blade and its platinum contacts are out of adjustment.
3. There is grease or oil upon the make-and-break spring, if a non-trembler coil is in use.
4. The condenser has somehow become disconnected or punctured.
5. The high-tension windings on the coil or the high-tension wire have partly broken down their insulation.

Therefore, switch over to your spare battery; clean the platinum points of your spring contact by rubbing a visiting card between them or even by smoothing them out with a very fine file and removing all filings very carefully. The condenser trouble is not curable on the road, but you may be able to run your engine slowly home if you allow the compression cock to leak a little. If touring in remote parts it is worth while to carry a spare coil or even to have a complete stand-by ignition.

Damp.—Water is a conductor of electricity; therefore the

porcelain plug should be wiped after a damp or foggy run. The rubber-covered wires where they approach the terminals should also be kept dry. This will be found impossible if there is any exposed braid or tape to get damp and to collect and retain it. Therefore, remove the braid and tape from the end of all wires for a length of about an inch close to the terminals. Do not remove the braid from the entire length of the wire, because it is a useful protection against breaking and fretting, but dip the whole of the braided wire before using it into a bath of melted paraffin wax, wiping off the surplus.

Supposing that neither a spark nor a shock is obtained at the spark plug of the cylinder which is misfiring, it is generally safe to look in turn for one of the following defects:

(i.) The battery completely exhausted (try it with a voltmeter which takes the full normal current, say 1 ampere).

(ii.) There is a disconnection or a break in a wire—examine first the high-tension wire as being the simpler. See also that the switch has not accidentally been moved to the "off" position. See that the lead lug in the battery is not broken.

(iii.) The platinum tip has fallen off from the trembler blade or from the spring contact, or from the platinum-tipped screw; or the entire trembler blade has come loose from its clamp.

(iv.) One of the coils has completely broken down. If so, the click of a spark is generally audible by putting one's ear close to the coil-box.

In applying these various suggestions the reader is credited with a certain amount of acumen. Thus he will at once surmise that if only one of four coils fails to give a good spark it clearly cannot be the battery that has failed; indeed, trouble in this case is not to be expected in any part which is common to the whole four coils, as, for example, the ground wire, or the switch, or the commutator, save at the one contact corresponding to the one cylinder showing the faulty ignition.

Cleaning Sooty Plugs.

With a two, three or four-cylinder motor, it is quite possible to clean a sooty ignition plug without removing it from the cylinder. The "modus operandi" is as follows: Detach the high-tension wire from the misbehaving plug, open the compression cock of its cylinder, and run the engine on the other cylinders. Then hold the terminal of the detached wire, being very careful not to touch the metal part with the fingers, a very short distance off the end of the plug, so that the spark jumps to the latter. The wire should be held by the insulated part at least two inches from the bared terminal. At first the cylinder will be heard to be missing, but very quickly the reverse will be the case, and the dirty plug will be found to have cleaned itself, as to all intents and purposes a spark gap is established. Then switch off, shut your compression cock, attach your wire again, and start up.

How to True Up the Contact Screw.

In devising a jig for trembler screw points, the simplest possible form, if there is no difficulty in getting either a "tap" which will fit the trembler screw, or in cutting a tap to do so, all that is necessary for the trembler screw device is to drill and tap a hole through a piece of ⅜-inch steel plate, ground perfectly true on one face, and then harden the plate. The hard, flat face acts as a guide for the file, insuring that it travels truly in the same plane, and the fact that the trembler screw is held by its own thread is a guarantee that the face of the point is at right angles to the line of the screw. This way of doing the point is the simplest, but supposing the trembler screw cannot have its thread matched without trouble and expense, the jig illustrated in Fig. 1 obviates any difficulty in this direction. It consists simply of a piece of cast steel bar, bent round as shown, and having the face marked D ground quite flat. Through the center of this portion of the bent steel a hole is drilled, which is exactly the size of the outside of the trembler screw, so that it will

just push in from the under side easily. In the illustration a slice has been cut out in front of the trembler screw A so that it can be seen. Exactly opposite this hole in the other arm of the bend, a second hole is drilled and tapped with any convenient thread. Through this hole the round-ended set screw B is inserted, its rounded end bearing beneath the milled end of the trembler screw. The steel bend and the screw B should both be hardened. To use this jig the

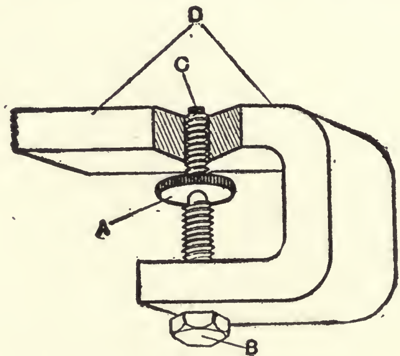


Fig. 1.

Jig for filing trembler screw points correctly.
A, trembler screw. C, platinum point.
B, adjusting screw acting as a stop. D, hardened flat face.

trembler screw is inserted, and the lower set screw B run up until the contact point C can just be seen, on glancing along the face D, to be sufficiently above that face to clean up quite flat. A fine flat file then steadied along the true face D will complete the operation, and a perfectly level surface will be obtained for the point C.

Truing Up the Blade Contact.

The jig for the trembler blades illustrated in Fig. 2 consists of a cruciform base, the central portion of which is bored and screwed to receive the circular table A. This table, which is shown separately in the left-hand corner with its shank in section, is made with a buttress thread as shown, and preferably its edges should be knurled or milled. Along one diameter of the base, and equidistant from the center of the table

A, are the screwed studs D D, which pass through holes in the two clips C C. These clips are as shown, and consist simply of two metal strips about ¾ inch wide and $\frac{3}{16}$ inch thick, bent over at the one end, and ground flat on the downturned face opposed to the top of the table A at the other. Along the other diameter the studs or stops B B are fixed, these being screwed into the base and made from hard steel. The upper faces of these studs B B must be perfectly level, and exactly the same height from the base plate.

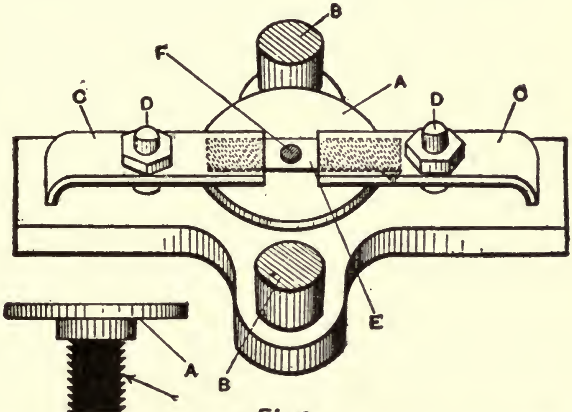


Fig. 2.

Perspective plan view of jig for filing the points of trembler blades flat.

A, adjustable table with buttress threaded shank.
B B, hard steel studs for grinding the file.
C C, clips holding blade to table.
D D, studs and nuts for tightening clips.
E, trembler blade.
F, platinum point.

The method of procedure is as follows: The trembler blade E is laid down on the table A with the platinum point F upwards. The clips C C are slipped over, so that the trembler blade is between the lower faces of the clips and the table top, but the nuts on the studs D D are left quite slack. A straight-edge is then held across the faces B B, and the table screwed up until the point F comes into contact with it. The straight-edge is removed and the table taken up just a shade more, according to how much has to be removed from the platinum point F. The nuts on the studs D D are then tightened down gently, when the blade is gripped firmly against

the surface of the table; and, moreover, since the table has a buttress-threaded shank, the pressure locks the table very securely in position. A fine file is then run across the studs B B, with the result that the point F is made quite flat and true with the blade in both directions.

Two steel plates, identical in shape, which can be clamped together by a pair of thumbscrews, and having a 3/8-inch hole drilled completely through the two, make an excellent jig for holding the end of the trembler blade when filing the hole to secure coincident setting of the points, this obviating straining or bending.

Adjusting Contact Breaker Screws.

In adjusting the contact breaker screws when the contact breaker is of the positive make-and-break type, care should always be taken to see that the small locking screw, which is provided in the split end of the screw-supporting pillar, is properly locked after the adjustment is complete. Also, it should be noticed whether locking up this screw affects the adjustment of the contact screw, as this sometimes happens. When the contact-making screw is not properly locked up, the constant tapping on it of the trembler blade invariably works it farther back, so that the adjustment does not keep correct for any length of time, and, consequently, the annoyance of misfiring is experienced very frequently.

A Cause of Irregular Firing.

Automobilists who have had experience with the old De Dion type of contact maker have at some time or other been troubled with irregular firing of the cylinder charge. This has been put down to various causes, chief of which, no doubt, has been a dirty contact between the platinum-pointed adjusting screw and the trembler blade. Other causes are loose contacts, either at the plug wires or in the primary circuit, dirty sparking plugs, nearly run-down battery, or a bad mixture.

A not infrequent cause of trouble, however, is due to the fact of the hole in the insulating quadrant of the contact

maker itself wearing slack or oval. The constant knocking action of the notched cam on the trembler V-piece in time causes an oval hole in the quadrant, and consequently the correct action of the trembler is interfered with, and frequent adjustments of the screw become absolutely necessary. When the quadrant wears oval, it can be repaired by bushing it with gunmetal, but probably a more satisfactory method would be to fit a new contact maker.

A more lasting quadrant would be one made entirely of metal, a good hard gunmetal for preference, in which case the adjusting screw terminal and connections would have to be insulated by means of wood fiber or ebonite washers, and there would be no necessity for a ground wire to be the trembler terminal, as it would be constantly grounded through the metal quadrant. This has been employed in certain cases, and has given every satisfaction.

Trembler Contact Treatment.

When coil tremblers are behaving badly and require filing, it may happen that a suitable file is not at hand. Then a fairly good new surface can be obtained on the platinum end of the screw by tapping it lightly with a small smooth-faced hammer.

Loose Contacts and Faulty Firing.

A case is reported of a somewhat curious source of trouble in connection with a two-cylinder engine. The engine suddenly refused to fire, and after much trouble and delay in testing wires, etc., the fault was found to be ascribable to a loose platinum tip in the trembler adjusting screw. At first sight the platinum showed about one-sixteenth of an inch clear of the end of the screw, but when tapped with a hammer it disappeared entirely within the screw. The trouble disappeared altogether when a new screw which had its platinum point quite firm was fitted.

Trembler Fatigue.

It is pretty certain that ignition troubles are occasionally caused by trembler fatigue. A case in point which once oc-

curred to a motoring authority would go to prove this. His engine would drive for from forty to fifty miles perfectly, running the car up all ordinary grades on its fourth speed; but shortly after that distance had been covered, one of the cylinders would begin to fire irregularly, and nothing would improve it. Coil trouble was suggested, but he was loth to believe this was at the root of the evil. The erring cylinder would not drive the crankshaft alone, when the tremblers of the other three cylinders were prevented from vibrating, although either of these three would perform fairly well by itself. No sooner was a new trembler fitted than the aforesaid weak cylinder ran merrily by itself, and the owner was moved to replace the remaining three old tremblers with new ones. These replacements greatly improved the firing and pull of all the cylinders, so that he was forced to believe that the old tremblers, which had been in constant use for eight months, wanted a rest.

Pitting of Trembler Contacts.

An annoying trouble, which in many cases is only a too frequent occurrence, is the pitting of the platinum contact on the trembler blade on high-speed trembler coils. The coil will sometimes work fairly well at slow speeds, but gives frequent missing when the engine is run at its normal rate, or accelerated. On examination of the platinum points mentioned, it is found that the screw appears to have its end melted in the form of a rough cone, like the carbon of an arc lamp, while the platinum on the blade is eaten out cup-shaped similar to the second carbon. It would therefore appear that the metal was volatilized at one point and deposited on the other. The probable reason for this may be the use of an inferior platinum alloy, which has a comparatively low melting point, and is, therefore, more readily volatilized than pure platinum. Pure platinum does not stand the rapid knocking at the high speeds the trembler works at, and hence an alloy of platinum and iridium is largely used, and this probably follows the rule that the melting point of an alloy is lower than that of either of its constituents.

In many cases frequent adjustments of the trembler screw and trimming up of the points only cure the trouble for a time, and lead to the conclusion that there is also some inherent fault in the coil itself.

Extra Grounding Wire.

"My 6½ H.P. single-cylinder engine had always been a trouble to start, but once going would run well," writes a European motorist. "Complete rewiring, a new sparking plug, shifting the non-trembler coil nearer to the engine, and a general clean up of all the electrical fittings did not improve matters. Finally, a second ground wire was attached to the coil, ending at the blade of the contact breaker, and the engine now starts without hesitation. The question now is, Why was the first ground wire ineffective? It was a good wire from the coil to a bolt holding the engine to the frame of the car. The platinum-tipped screw is insulated, but the trembler blade is attached to a metal segment moving about the half-time shaft as usual. The only explanation I can give is that the thick oil from the crankcase proved an insulator, a film of this lying around the half-time shaft between it and the metal segment. While the engine was at rest this oil more or less set hard. Upon trying to start the engine, it was necessary, by a long period of starting handle exercise, to wear through this film of oil until the one metal surface of the half-time shaft rubbed against the other metal surface of the segment. This has now been saved by giving an alternative path direct from the blade to the coil."

The Trembler Coil.

Many motorists would be glad to have an explanation of the reason why a trembler coil is necessary with a wipe contact, and the difference between an ordinary coil without and the coil with a trembler. To summarize the reason, it is necessary to break up the primary circuit of the coil rapidly—that is, the current which flows from the source of electrical energy through the coil. This interrupts the lines of the magnetic field, and intensifies the power of the induced cur-

rent, for the quicker the make and break at the trembler, the more effective is the spark, or, rather, the shower of sparks, at the plug, such a shower being much hotter than those of lesser density produced by a slow vibrating trembler. That is why, as a rule, the magnetic trembler is much more effective than the mechanical trembler, for the latter cannot work up to the speed of the former.

A Cause of Misfiring.

An engine, after being in use for some time, will often misfire, and the cause be difficult to ascertain. Frequently the trouble is one which does not occur with a new engine. If the contact breaker is of the make-and-break type, the bearing of the contact maker may have worn and the current find difficulty in reaching "earth." To obviate this, a stranded wire, which need not be insulated, may be led from some part of the motor to the screw which holds the trembler blade in place. Then the current travels directly from the trembler to the earth without having to go through any sliding joints. etc. In a wipe contact maker, it will be often found that the brass is worn flush, or lower than the insulation, the result being that the wiping blade jumps the brass at high speeds. The insulation can easily be removed near the brass, which will cause it to operate as before. Contact breakers of this type should always be oiled, as it prevents the wiping blade carrying the insulation on to the brass, which it frequently does owing to its wiping action, the result being misfiring at high speeds. Again, misfiring such as this is often due to the wiping blade having lost its stiffness, and not bearing sufficiently hard upon the contact breaker cam, which may have worn as well.

Misfiring Through Defective Insulation.

Much annoyance is often caused to the user of a motor car by occasional misfiring which he finds a difficulty in locating. We cite a case of this kind, where for a time the engine would run perfectly, and then most unaccountably commence to misfire. This alternated with periods of regular running and

irregular running. A thorough examination revealed no defects—the battery was fully charged, coil worked perfectly, and the contact maker made good contact—but still, as stated above, trouble was experienced repeatedly. It was noticed, however, on turning down the front of the coil box, that the high-tension wire of one of the coils was brought very close to the low-tension wire of the other, and the owner found that, instead of this high-tension wire being thoroughly protected by its insulation, at intervals a spark would leap through the insulation to the low-tension terminal before mentioned, and a misfire thus be caused in one of the cylinders. Removing the wire to a distance of about half an inch from the other terminal immediately corrected the fault, and no further trouble occurred.

In such cases of misfiring it is always advisable to inspect all wires which touch a metallic part of the frame, as, owing to the vibration of the engine, the cause may be at these points.

Marks on French Induction Coil Terminals.

The marks upon induction coils of French manufacture are not understood by a great many users, and therefore an explanation of them may be of interest. There are usually three terminal screws upon the coil for a single-cylinder engine, and these are marked P, M and B; P and M usually being at the side of the coil at the top, and B either directly at the bottom or lower down on the side. The terminal marked P is connected to the positive terminal of the storage battery by an insulated wire into which the contact breaker is interposed. There are, of course, many variations in the wiring of the connections to the coil, and the one given herewith is only one of them. The terminal M, which, by the way, on some French coils is also marked V, is connected to some metallic part of the frame on the car, or to the engine itself, and forms an earth or ground return to the negative terminal of the battery, a further piece of wire being connected from this terminal to the framework to complete the circuit.

The terminal B is the one to which the high-tension wire connecting up to the plug should be attached.

Numbering the Coil.

On three and four-cylinder engines fitted with trembler coils, it is always well to take an early opportunity of verifying the trembler for each cylinder. For instance, assume that a four-cylinder engine is missing on one or two cylinders. The bad cylinder is ascertained by holding down the trembler blades and making the engine run on one cylinder at a time. When we come to the bad one, the engine stops unless the other blades are quickly released. Despite this we find that all four tremblers are buzzing merrily in turn, and apparently there is nothing wrong with them. It is therefore natural to assume that the plug is at fault, and the question at once arises, which plug? There is nothing for it but to unscrew them one by one, and to turn the engine round to see if the one under examination is sparking out of the cylinder. In the usual course of things it will be the last plug one takes out which is found to be foul or otherwise at fault. On the other hand, if we had known which buzzer belonged to each plug, we could have gone straight to the foul plug and have cleaned it up or put in a new one without loss of time. However, as we have got our four plugs out, we might just as well count them off from the front. Call the one nearest the radiator No. 1. Turn the engine round slowly, and when you see the plug on No. 1 sparking, go round to the trembler coil and see which of the four tremblers is buzzing. Then pencil on the trembler case opposite to this trembler No. 1. Continue the operation until you have numbered the coil for all four cylinders. Of course, we know the engine does not fire 1, 2, 3, 4 backward, but that does not matter; we only suggest numbering the coil so that it can at once be seen which trembler and which plug are connected, so that in future, whenever there is a cylinder not firing, we can safely assume, when we have played the usual four-finger exercise on the coil, that the plug on a certain cylinder is wrong. We no longer need blunder through all four.

General Troubles with Coils.

Looseness of platinum screws in the bridges.—Whether these are bound with a lock-nut or not, they offer resistance to the primary current.

Armature rubbing against the guide screw.—This restricts the speed of the armature. Allowance is made for this in some armatures by making the hole in the armature through which the binding screw passes slightly larger than the screw stem.

Shorting of the secondary current to the coil support angles or ears, due to the screws which hold the angles to the case being too long and projecting inside.

In the case of four-cylinder coils (not waxed in entirely) the ebonite top breaks away, owing to the screws which are passed through the case into the ebonite top chipping out pieces of ebonite, and so losing their hold of the top. This is very often caused by the windings getting loose, and may be caused by a jar to the coil.

Breaking of the primary wire between the communication screws on the ebonite top and the terminals, and between the communication screw and the bobbin itself.

Breaking of the flex wire between the bobbin (high tension) and the terminal.

Internal switch troubles, due to wax entering the switch and greasing the metal contacts.

Buttons on the armatures (which draw down the platinum blade) getting loose and causing erratic striking of the platinum blade. In the case of some distributer coils this may be the cause of knocking in the engine.

Button of the armature shorting on the platinum screw.

Stiffness of the distributer armatures—in those cases where it is of springy material and has no spring underneath to help its return movement. This stiffness causes misfiring at high engine speeds.

Many owners have had cases of coils bubbling the wax out. This has been in most cases where ordinary coils have been used for distributer purposes. They have noticed also that with certain distributer coils with the bobbins waxed sepa-

rately all the insulation off the bobbin melted down to the bottom of the box. This probably was due to the coil being placed inside the bonnet near the engine.

In large heavy two, three and four-cylinder coils the wooden cases have split, especially where angles are screwed to the wood. As an opposite example to this, the case is cited of a four-cylinder coil where the wood of the case and front flap was half an inch thick. It looked a very substantial coil, and would probably stand rough usage. The top had hinges, and front flap hinges were also much stronger than usual. Where flaps in covered-in coils are used the hinges are often loose. The same applies to the top lids. This is accounted for by the thin wood used in the case construction, which necessitates small screws being used to screw on the hinges.

Commutator Short Circuiting.

Good as rolling contact commutators undoubtedly are, yet nevertheless trouble may arise from them and within them which the automobilist may be long in diagnosing if he has not been informed that its happening is within the bounds of possibility. After considerable use, the friction of the roller over the metal contacts has the effect of wearing off small particles of the metal and gradually laying these on the fiber ring in the form of an embedded train, which will ultimately connect one contact with the other, so that the current will short all round, and whether two or four cylinders are served, current will pass to all the sparking plugs at once. If this has happened, the only thing to do is to detach the fiber ring and scrape the inlaid metal from its surface. These remarks apply with even more force to the commutators made on similar lines, but which have a rubbing in lieu of a rolling contact.

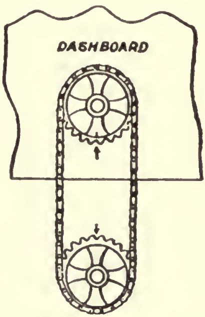
A Mysterious Squeaking Noise.

Sometimes a motor will develop a mysterious squeak when running, and this often takes a good deal of locating. Many motors are fitted with the wipe type of contact maker, and it is well to look to the wiper blade and the disk on which

it rubs for the source of the squeak. If the disk is allowed to get dry, a most distressing noise is caused by the rubbing of the steel wiper piece on the fiber of the disk or by the bearing of the roller on the wiper arm when the latter is rotated. A spot or two of ordinary lubricating oil will effectually cure the trouble.

Adjusting Commutator Chain Drive.

If a chain-driven commutator upon the dashboard is used, it should be remembered that a great deal of difficulty will be experienced in getting the chain correctly replaced if it is taken off for any purpose. Of course, where a spur gear is employed to drive the commutator, it is perfectly easy to mark one tooth and the bottom of the two opposite teeth into



which it engages, thus insuring correct timing; but with a chain drive it is impossible simply to mark two teeth alone. This may be done to a certain extent with satisfaction, however, by marking the rim of the wheel on the center line; it then becomes a matter of the eye in replacing the chain, and also one of memory to insure the marks being in correct position, that is, both marks should be at the bottom or top of the wheel, as originally placed when they were indicated. One writer suggests pointers being attached to convenient parts, the marks on the chain wheel being brought opposite to these. In any case, it will, of course, be necessary to ascertain roughly the relative position of the crankshaft to the camshaft. Unless this is done, it is quite possible to get the set-

ting incorrect, as while one wheel may be in position correctly, the other may be a revolution before or behind it.

Twisting Temporary Connections.

In making a temporary electrical connection, the stranded wires should be twisted up as solid as possible, and the loop formed by turning the wire from left to right. When so made, the loop closes in under the twisting action of the screw when tightening up the connection. If the loop be made in the opposite direction, this same action spreads the wire, and a bad connection results.

Contact Breaker and Commutator.

The terms contact breaker and commutator are at present being very loosely used in connection with automobiling, simply on account of their functions not being definitely and clearly understood. To all intents and purposes, both serve the same purpose, which is that of an automatic switch completing the circuit of an electric current at a given time. The contact breaker, whether it be of the spring blade or of the wiping contact type, is used in connection with single-cylinder engines only, while the commutator is used on multi-cylinder engines, though its type and design may be precisely similar to that of the wiping contact breaker on the single-cylinder engine. The very word "commutator" should be sufficiently expressive to prevent this error, as its meaning clearly shows that its mission is to "commute," or to exchange, the current from one path to another—that is, of course, from one cylinder to another. It could only be a contact breaker when each cylinder was supplied with a separate source of electrical energy, and with a separate coil, though when the common source of supply is from a single storage battery, notwithstanding that it traverses a separate coil for each cylinder, it then becomes a commutator.

Multi-Cylinder Ignition Timing.

There are still a few makers of four-cylinder engines who adhere to make-and-break ignition contacts as their standard,

and when perfectly adjusted and tuned up, this ignition is quite as satisfactory as the trembler coil and wipe contact; but when the slightest derangement occurs, the trouble is difficult to locate, and often inexplicable. Presupposing that all the platinum contacts are in good condition, and that each cylinder is firing in its turn, it is yet quite possible that anything but the best results are being obtained. The defect arises solely from faulty ignition timing, due to the fact that the points of the platinum-tipped screws and blades are not all equally adjusted. Thus, if we suppose our four tremblers to be adjusted with No. 1 set of points 1 millimeter apart, No. 2 set 1.5 mm., No. 3 set 1.4 mm., and No. 4 set 1.2 mm., the cam having a 3 mm. eccentricity, each and every trembler will give a spark at its full power; but if we suppose that trembler No. 1 is firing accurately, No. 2 is firing late, No. 3 late also but earlier than No. 2, No. 4 earlier than either No. 2 or No. 3 but later than the correct No. 1, the terms late or early being, of course, relative to the position of the piston. Thus, in each cylinder the mixture is being ignited at a different period, with the result that, if No. 1 is being fired to its best advantage, the other three cylinders are not igniting efficiently, the balance is gone, and considerable power is being lost. Beyond this, where the firing is late, the combustion is not completed until after the exhaust valves have opened; the burning charge passes out in the form of a flash, extremely detrimental to the exhaust valve heads, and tending to overheat the engine. In order that the best power may be obtained, each cylinder must explode at relatively the same point, and, therefore, when adjusting the make-and-break mechanism, great care should be taken to see that exactly the same distance separates the contact points.

On Preignition.

If preignition occurs, the engine should at once be stopped and examination be made, as it is the chief cause of bent connecting rods and broken crankshafts. The chief cause of preignition is failure of water circulation. If this should be suspected, it can be proved easily whether it is at fault by

placing the hand on the radiators and water-jacket. If the former are almost cold, while the cylinder jacket is exceedingly hot, it will at once be understood that the pump is not working, or that there is an air-lock in the radiator piping. The best way to deal with the failure in either of these cases is to disconnect the outlet pipe from the pump and run the engine. If the water is not discharged, it is obvious that the pump is not working, while, on the other hand, if the water tank is filled up while the engine is running, the air-lock will probably be removed. Intermittent preignition is rather more dangerous than persistent preignition, because the latter pulls the engine up, while the former, coming at rare intervals, is far more likely to do damage owing to the driver neglecting to take precautions. A frequent cause of intermittent preignition is a short circuit in the contact breaker wire. This may be due either to the insulation of this wire becoming chafed and short circuiting to "ground," or to an errant strand at the contact breaker terminal, which frequently touches some part of the motor and "shorts."

A third cause puzzled an experienced motorist for a long time. The symptoms were of persistent preignition. The pump was suspected and overhauled. The water was emptied away and the tank refilled with cold, but before the car had traveled a hundred yards the owner was forced to stop the engine again, when, of course, he knew it was not the water circulation, but something inside the cylinder. On removing the valve caps, he found in the cylinder pieces of porcelain which had broken off the inside of a porcelain sparking plug. The central wire was held in place, and the plug was firing quite normally. These pieces of porcelain naturally got excessively hot, and caused the preignition. The owner had difficulty in getting rid of the pieces, but when removed preignition ceased.

Experiences: The Value of Diagnosis.

The foregoing hints are the result of an interesting personal experience, for faulty ignition resulted in a 16 H.P. car doing but sixteen miles an hour on the level with its levers in the

45 m.p.h. position, and reduced to a miserable crawl up anything like rising ground. The symptoms at first were precisely similar to those produced by the butterfly throttle valve having become loose on its spindle, but this was after a time proved to be an incorrect diagnosis. Next the governor was attacked, but, being found in order, the operator looked to the carbureter, rather expecting to find the gasolene supply choked to a slight extent, but everything was found clear. Between these investigations the car was run for a few miles, so that a chart of times and distances would have presented the appearance of the toothed edge of a saw. However, the operator tackled the ignition, and soon found a somewhat considerable blowing at the ignition plates (this being tested by pouring a little oil around the spindles of the tweakers) and considerable maladjustment. So much for the value of theory and diagnosis. We do not deprecate the system of observing symptoms and following them out to the end, for in a high percentage of cases the correct trouble is found, but, as we have shown, on occasions one is apt to be led far away from the actual ill. The ignition in the above case, by the way, was low-tension magneto.

Insecure Terminals.

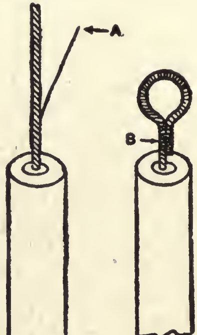
Cars are sometimes sent out with stranded connecting wires just twisted round all the terminals, and there held by the screwing up of the terminal screw. We would strongly advise any automobilist who finds his new car wired in this careless and shiftless fashion to get proper terminals soldered on without delay. It will save both time and temper in the long run. Moreover, from frequent bending round the terminals, the stranded wire breaks, and one often gets nasty, painful pricks in the fingers therefrom, which smart and are sore for some time. There can be no sort of excuse for sending out cars wired up in the slipshod way we have referred to. and the purchaser of a car should see that it is put right.

Varnish for Electric Terminals.

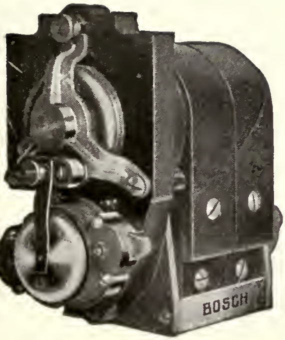
Electric terminals which happen to be in such a position as to be subjected to water or mud accumulating upon them can be effectually prevented from possible short circuits by painting them with a varnish composed of ordinary red sealing-wax dissolved in a little gasolene. This varnish is made by putting into a small bottle a quantity of small pieces of sealing-wax, covering the latter with spirit and occasionally shaking it. If the varnish should prove too thin, add a little more wax or leave the cork out of the bottle until some of the spirit has evaporated. If it is too thick, add sufficient spirit to bring it down to the required consistency. In order to prevent the varnish retaining the brittleness of the sealing-wax, a little linseed oil should be added. For those who do not care to go to this trouble, a little melted paraffin-wax can be used for the same purpose. The ordinary wax candle contains paraffin-wax of sufficient quality to do this. Either of these methods has been found as satisfactory as binding with insulating tape.

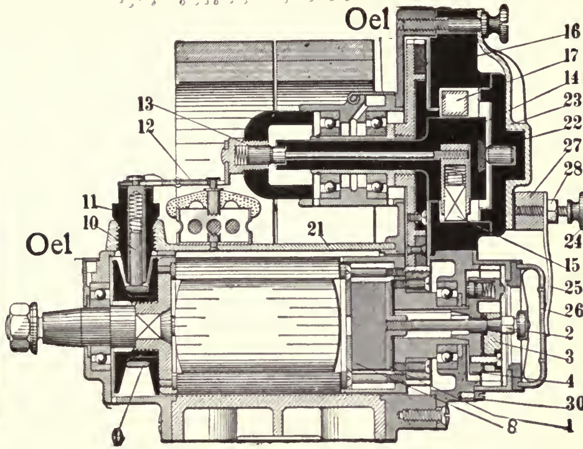
Making Electric Connections.

A sketch of an excellent method of making electric connections with the wire itself is given herewith. The insula-



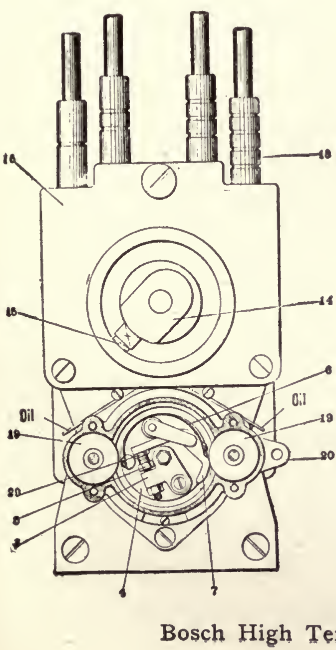
tion must be cut round at a convenient distance from the end, 1¼ inches to 1½ inches usually being the extreme amount required to make a connection. The stranded wires should be





Longitudinal Section.

Back View.



1. *Brass plate.*
2. *Contact-breaker screw.*
3. *Platinum screw block.*
4. *Contact-breaker disk.*
5. *Long platinum screw.*
6. *Contact-breaker spring.*
7. *Contact-breaker lever.*
8. *Condenser.*
9. *Slip ring.*
10. *Carbon brush.*
11. *Carbon holder.*
12. *Connecting bridge.*
13. *Contact carbon.*
14. *Rotating distributor piece.*
15. *Distributor carbon.*
16. *Distributor disk.*
17. *Metallic segments.*
18. *Contact plug.*
19. *Fibre roller.*
20. *Timing lever.*
21. *Dust cover.*
22. *Cover.*
23. *Triangular clamp.*
24. *Nut for switch wire (short circuit).*
25. *Spring for fastening brass cap.*
26. *Brass cap.*
27. *Brass block for fastening spring of brass cap.*
28. *Fixing bolt.*
29. *Short platinum screw.*
30. *Stop screw for timing lever.*

Bosch High Tension Magneto—Type DR4.

twisted tightly together; one or two of the wires, according to the thickness of the strands of which the cable is composed, are taken apart, as shown by A, the cable then being retwisted. The wire should then be formed into a loop round a piece of metal or the terminal itself to a nice easy fit. The end of the wire after forming the loop should lie parallel to the wire at the beginning of the loop. The stranded wires which have been taken apart are then used to bind the end of the loop to the main body of the cable, the whole being soldered together with soft solder, which will flow easily without having to use a great deal of heat. Particular care should be taken to use resin, instead of hydrochloric acid reduced by dissolving zinc in it, or one of the many acid soldering fluids sold. The objection to using such fluids is that they set up corrosion and a chemical action at the joint, offering a high resistance to the current, and there is no doubt that the same cause is responsible for the ignition delays which some motorists experience with their cars.

Broken Plugs.

Sparking plugs with loose and leaky centers are by no means uncommon; but, treating the matter generally, very few people try to discern and remedy the cause of the trouble. More often than not the source of breakage can be traced to the festoons of heavily-insulated wire pendant from the plug terminals, or, where a neater and collective arrangement is employed, to the tighter wires from the overhead stay to the plugs which transmit the vibration to a considerable extent, resulting in a breakage. There are two methods by which this transmitted vibration can be obviated entirely, and the life of the plug increased considerably. The one is to solder a fine coil of flexible wire to the end of the high-tension cable, support the cable firmly, and connect up the remaining end of the coil to the plug terminal. In this manner the weight of the cable is taken completely from the plug, and the fine coil is quite incapable of transmitting the vibration.

A similar arrangement—one which performs the twofold functions of spark gap and non-vibrating connection—is now

fitted to a number of engines. From each high-tension terminal to the plug terminal is fitted a light brass or silver chain, down which the current runs to the plug, having a minute spark gap, as a rule, between each link; but all uncovered sparking gaps are dangerous.

Spark Plug Troubles.

If the porcelain body of a sparking plug allows a loss of compression at the packing gland, it is often only necessary slightly to tighten up the hexagonal top of the circular portion of the gland. After doing so, the plug wire should be inspected to make sure that any slight rotation of the porcelain does not affect the adjustment of the two points, otherwise some misfiring or entire failure to fire the charge may result. Another frequent cause of maladjustment of these points when the plug is new is the screwing of the plug into the cylinder. When the wire attached to the metal body of the plug is hammered into position the thread is usually burred slightly. This is restored to position when the plug is screwed into the cylinder, and the wire is slightly moved in consequence. When new a plug should be filed at the thread by means of a triangular or fine half-round file, to remove the bur. The plug should be screwed home, and then removed and examined to see that the position of the wires is not varied, after which the plug can be again screwed into the cylinder, with the certainty that it will work correctly.

Warped Spark Plug Porcelain.

An Eastern motorist experienced a rather uncommon failure, accompanied by misfiring and a peculiar blowing noise in one cylinder. As the valves had recently been ground-in in all the cylinders, and no compression cocks were used, the trouble could not be located until kerosene was squirted around the valve caps and over the sparking plug. Turning the starting handle round, it was found that gas blew past the porcelain of the plug of the misfiring cylinder, though from what one could see the plug was in proper condition. On removing the plug and taking it to pieces, the porcelain was found

to have warped considerably. There is no doubt that the porcelain was not true in the first place, and from some unknown cause the packing which secured it had loosened sufficiently to allow an escape of gas past it, and so caused the trouble.

A Crack in the Porcelain.

When misfiring takes place, one usually in the first instance examines the sparking plug, which is supposed to be the offender, for deposits of sooty matter or lubricating oil. In a number of cases it will be found that when the soot or oil on the porcelain has been washed off with a little gasolene, and the sparking points cleaned with fine emery or glass-paper, a very good spark is seen between the points when the metallic body of the plug is laid on the cylinder and the necessary contacts made. Yet on replacing the plug it is found that the misfiring in this particular cylinder is just as bad as ever. This is a most deceptive and annoying trouble, which will often be caused by a crack in the porcelain, either close to the wire terminal and almost imperceptible, or it may be somewhere inside the body of the plug, and therefore cannot be seen. A good spark is produced in air, but under the compression at working conditions the spark passes from the center wire through the crack in the porcelain to the metallic body of the plug, as this offers a relatively easier path than that between the points and through the compressed mixture. If the plug is held with the metal body in one hand and the porcelain in the other, and a twisting action backward and forward is applied while the plug is held close to the ear, a slight grating sound will be heard if the break is inside the body of the plug, which should be at once discarded in favor of a sound one. A new porcelain may be fitted to the defective plug if desired. Great care should be exercised in putting in or taking out plugs from the cylinder, as there is every chance that the porcelain may receive a slight tap with a spanner and be broken, porcelain being extremely brittle. This particularly applies in cases where plugs are placed in deep recesses and a box or tube spanner is required for insertion or removal. If the packing in a plug is screwed

up too tightly, the heat is very likely to cause the porcelain to crack. The stuffing gland only requires tightening up to such an extent as to prevent loss of compression in working.

A Spark Plug Joint.

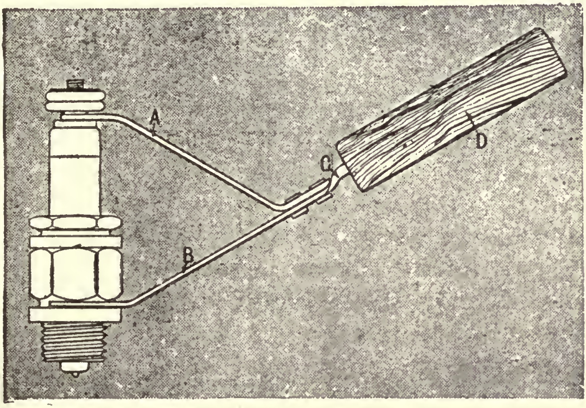
Often on the road it is found that a loss of compression is taking place past the copper washer beneath the spark plug flange, and that a spare washer is not available. An excellent substitute can be made by cutting a piece of $\frac{1}{16}$-inch copper wire the right length and bending it round circularly so that the ends overlap. Then give each of the overlapping ends a tap with a hammer to reduce the thickness to about one-half, and so that they fit together fairly. On screwing up tightly it will be found that this will make a sufficiently good temporary joint.

A Simple Spark Plug Cut-out.

The method usually employed for testing an engine—by cutting out the ignition of all the cylinders but one—is a very simple and useful one. Where a trembler coil is fitted the usual method is to hold down the tremblers of all the coils except one, allowing only one of the cylinders to work. Where a non-trembler coil is fitted it is more difficult to cut out one cylinder. For this purpose a wire has to be disconnected either from the contact breaker or the coil. The device which we illustrate herewith is one which is intended to overcome this difficulty, and may be used with any kind of sparking plug, whether operated through a non-trembler or trembler coil or magneto.

The device merely consists of a fork of some thin strip conducting material, the ends of the arms A and B of the fork being split, while the handle portion C is driven into an insulated grip D. To cut out the ignition of one cylinder this device is held up to the sparking plug of that cylinder, so that one arm touches the terminal of the sparking plug and the other either the body of the plug or any part of the engine. The current will now short circuit from the terminal through the arms A and B to ground without causing a spark

at plug points. One or the other of the arms can be fitted underneath the binding screws of the sparking plug, and the device bent upward or downward, so as to bring the other arm into or out of contact with the body of the plug, and so



provide a fixed cut-out, which can be used during testing somewhat after the manner of the cut-out plugs used on some magneto ignition systems. This is a little instrument which can be made by anybody and carried in a toolbox to be used when required.

On Testing Ignition Sparks.

In one of his interesting articles on electric ignition, Mr. C. E. Duryea gives a useful tip for testing either low or high tension sparks. To test the high tension spark, "pass a strip of paper between the points of the sparking plug, and the paper will be perforated by the sparks, leaving a line of minute holes. To get the actual size of the spark in the cylinder, the points should be separated a quarter of an inch or more, for it is well known that the compressed air is an insulator, and that engines which frequently miss on full charges will fire regularly when throttled, thus proving that there is a larger and better spark when there is no compression.

"To test the make-and-break low-tension spark in a similar manner, connect one wire from such a system to a piece of

sheet metal on which is placed a sheet of thin paper, preferably held about 1/32 inch above the metal. Connect the other wire to a common pin, and push the latter through the paper. Then pull the pin away quickly. A large spark will follow, burning a hole through the paper, frequently an eighth of an inch in diameter. Compare the area of this hole with that of the minute perforation made by the jump spark, remembering that the make-and-break spark is also longer, and it will be seen that the volume and heat of the make-and-break spark is much larger, on which account it will fire a less perfect mixture."

Setting Up New Spark Plugs

In setting up a new sparking plug, the first thing to be seen to is that the ends of the platinum sparking points are flat and parallel. In cutting off the wire for these points a pair of cutting pliers is used, with the result that the ends are left in the shape of a broad V. Now, as the sharp edges of the V are likely to be at any angle to one another, it generally happens that the actual sparking areas are but little more than equal to the diameter of a very small pin. The natural result is that a weak spark is produced, and the novice may look for a very long time before finding the real cause of it. What is required for the highest point of efficiency is two flat surfaces parallel to and opposite one another—simple conditions, but difficult to fulfill.

A Point Position Gauge.

To attain the best conditions for the sparking plug points, it is first necessary to reduce the V points to a flat surface, and this is best done with a jeweler's or any thin flat file. Having got the points up flat and parallel, they must next be set up to their correct distance. This distance is variously given as 1 millimeter, 1/32 inch, and "the thickness of a visiting card," but the distance really depends upon the power of the coil and the resistance offered by the compression of the cylinder charge. Naturally, a powerful coil with a good voltage behind it will give a "fat" and hot spark, but this

may easily be offset to a certain extent by high compression. The best practice is, then, to find by experiment the most efficient position of the points, and to have a permanent guide in the form of a gauge to set them up to. This gauge may be a piece of sheet metal, and once obtained should be religiously preserved.

Screwing in New Plugs.

Before screwing a new sparking plug into its place in the cylinder head, always file down to the thread level both in the groove and over the diameter the small hump which is usually raised by the fixing of the sparking wire to the metallic body of the plug; otherwise, although the points are correctly spaced before screwing the plug into its place, there is a tendency to alter their relative positions on screwing in, and thus to cause failure in working. Always make sure that the center wire is fixed properly, otherwise if it can be moved readily the probability is that there is a bad connection, and trouble with misfiring will follow. Before putting in a plug, if the screw thread is lubricated with graphite or blacklead, it is more easily screwed in or out.

Periodical Examination of Spark Plugs.

Because your engine starts up well first time round every day, runs well to the ear, and seems to pull all right, do not leave your sparking plugs unexamined from one month's end to the other. You will insure the extra touches of speed and power if you take these fittings out from time to time, say once a fortnight, and scrape all the hard carbon off them, cleaning them finally and nicely with a stiff toothbrush dipped in gasolene. Engines with high compression will be improved by this little attention.

Simple Test for Short Circuits and Broken Circuits.

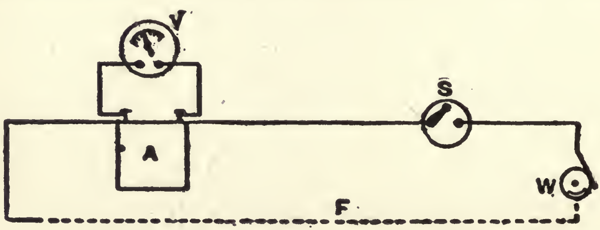
When troubles occur in connection with ignition, there is usually no method other than minute examination adopted for investigating the condition of the wiring in the primary circuit. Short circuits to the frame owing to chafing or cut-

ting of insulation, and total disconnection owing to hidden breakages in the wire itself, are not unknown, so a simple means of testing for these faults may be of value. When batteries run down rapidly while at rest, the blame is put upon the cells themselves, but in reality it may be due to defective insulation of the primary circuit.

The instruments required for the test are usually ready to hand, these being simply a storage battery and a reliable voltmeter of fair size. On a peculiarity of the former the value of the test depends, for it is found that when a battery is on open circuit it gives a higher reading than when a current is flowing. The following actual readings illustrate this: Current flowing in primary circuit, 0, 1, 2, 3 amperes; readings of voltmeter, 4.05, 3.97, 3.92, 3.87 volts respectively. These readings can be taken advantage of for testing purposes as indicated below.

Short Circuit to Frame.

To test for a short circuit to the frame proceed as follows: Connect a voltmeter across the terminals of the battery (ac-



A, accumulator.
F, frame wire or earth.
S, switch.
V, voltmeter.
W, wipe contact maker.

cumulator), leave the switch open, and set the wipe or contact maker so that metallic contact is not made (see sketch). Take a reading of the voltmeter. Now close the switch, watching the voltmeter carefully while this is done. If the needle moves, showing a lower reading, it conclusively shows that a current is flowing through the switch; but since there is no connection at the wipe or contact maker (contact breaker, so called), this can only be due to a leakage. If there were

a leak between A and S, it would be detected by disconnecting the primary wire from one of the terminals of the battery; the voltmeter would then show a higher reading.

Short Circuiting at the Switch.

On one or two types of low-tension switches, the terminals to which the low-tension wires are connected are placed too near together. Consequently, if great care is not exercised when wiring up, there is always the tendency to cause a short circuit between straggling strands of the wire. In some cases, the edges of the terminal nuts are only about 1/32 inch apart, and the reader will readily see that if a loose strand is left when wiring up this might touch the other terminal and cause a short circuit. This does not matter so much when the engine is running, although, of course, the battery cannot be cut off from the contact maker, so that there is always a tendency to run the battery down when the engine is not working. A good way to decrease the risk of such a thing happening is, first of all, when wiring up, to see that no loose strands are left about. These should be nicely tucked under the terminal nuts, and after the ends are properly tightened up the whole of the nuts and the bare wire should be wrapped with insulated tape on which a thin layer of rubber solution has been pasted. A very neat job can thus be made, and one need not fear that any trouble will be experienced at this point, for the tape not only insulates the terminals, but prevents the nuts from working loose.

Broken Circuit.

To test for a broken circuit, due to breakage of a wire or bad connection at the terminals or frame, proceed as follows: Connect up the voltmeter as before, set the wipe or the contact breaker so as to make metallic connection, leave the switch open, and take the voltmeter reading. Now close the switch, and if the current flows, as it should do if the circuit is not accidentally broken somewhere, the needle of the voltmeter will move, giving a lower reading. This test may save a good deal of time spent in futile attempts to adjust contact-

points or tremblers. Since a strong current would pass through the coil when the points of the contact breaker or trembler are held together, as in this test, the switch should be opened again immediately the movements of the voltmeter needle have been observed.

Detecting Short Circuits.

Occasional short circuits, as a rule, give more trouble than the entire breakdown of the ignition system, because the symptoms are very much like carbureter troubles. A good and rapid way to test all parts of the ignition circuit is to run the engine in the dark, when the slightest leakage from the high-tension wires or along the porcelain of the plugs will be at once seen by the faint light which indicates the short circuit. If the high-tension insulation is carried out with a poor quality of rubber, or is too thin, "shorting" may take place at any part. The slightest film of moisture or lubricating oil on the outer part of the plug porcelain also tends to leading away the spark and cause misfiring.

Destruction of Insulation by Oil.

After a certain period of running most low-tension wires become impregnated with oil which is thrown upon them either from the crank case or from some revolving part of the engine. As is well known, oil is extremely bad for rubber insulation, and it also to some extent destroys the insulation when this is tape woven. The result is that any part of the low-tension wire which rubs on any metallic part of the frame is at some period or another just cut through slightly, or the insulation is opened so that contact of the low-tension wire is made with the frame. The result is, of course, a short circuit in the primary winding. This defect is one that is most difficult of location, because the vibration of the engine and car keeps moving the wire from contact. It would be well, in the case where insulation is found to be so impregnated with oil as to be liable to this difficulty, at once to rewire the circuit where required.

Ignition by Batteries—Causes of Failure.

Below, under the four heads of Sources of Current, Induction Coil, Wiring, and Commutator will be found nearly every cause for ignition failure, partial or entire. Although the list is somewhat awe-inspiring as to length, every source of trouble enumerated can be avoided by care and cleanliness.

Sources of Current, Storage or Dry Batteries.—Loose or dirty terminal or terminal screw. Whole or partial discharge of storage or dry battery. Internal short circuit. External short circuit. Connection between plates or elements of the battery broken. Loss of electrolyte fluid. Perforated leaky casing.

Induction Coil.—Loose or dirty terminal or terminal screw. Wire separated from terminal at inner end. Broken or fused wire in coil (rare). Faulty adjustment of trembler. Pitted or unevenly burnt platinum contacts. Insufficient insulation of terminal from which high-tension plug wire leads.

Wiring.—Bared wire. Wire insulation destroyed by oil. Wire fractured within insulation. Loose wire attachment. Terminal unscrewed or dirty. Broken earth wire. Bad or dirty contact of earth wire. Mistake in remaking connections. Poor or faulty insulation of sparking plug.

Commutator, with Trembler or Blades.—Faulty adjustment of platinum contact screws. Too far apart—misses. Too near—premature ignition. Bad or burnt-out platinum contacts. Dirty or loose unsoldered platinum contacts. Faulty insulation of platinum-pointed screw. Greasy, split or loose ignition plate. Horizontal play. Broken trembler or contact blade.

Rotary Commutator.—Contact roller arm loose on spindle. Roller worn on circumference or center. Roller spindle worn. Contact ring worn in ridges, either fiber or metal. Too little lubrication. Too much lubrication with thick grease. Carbon deposit on contacts if contact maker runs dry.

Sparking Plug.—Fouling by oil, carbonization. Fracture of porcelain insulation. Loose porcelain. Shorting through mica insulation by penetration of grease. Sparking points too remote or too near. Damp, greasy or dirty porcelain.

Loose central conductor. Bad assembly of plug. Old porcelain.

Cleaning and Adjustment of Mica Insulated Low-Tension Plugs.

On examining an igniter that has been at work for some time (two or three days' hard running), it will be sometimes found that there is a small amount of soot or carbonized oil on the mica insulations. When this is the case, the surface of the mica should be wiped, or washed with a stiff bristle brush and a little gasolene, or if in bad condition scraped till a new surface is exposed. If the micas are found to be sooty on the inside, it is evident that the motor has been running with too strong mixture, and every driver's attention should be called to it. The contact point between the wire and anvil should be kept in good condition, a file being passed between the two points should they become pitted or show much corrosion. The wire should be free in the bush between the collars, but no very perceptible longitudinal backlash should be allowed. The spark gap should be adjusted to within about the thickness of two or three igniter springs.

Ignition Adjustments, etc.

All renewals, adjustments and cleaning of igniters should be done at leisure, and the spare igniters should be kept in good condition, and should be tested in place after adjustment, so that should a change be made on the road, there is no doubt as to all being right. Should an igniter spark outside on the road to any appreciable extent, it may be set up without stopping the engine. To do this, the locking handle should be slacked off slightly and the adjustment screw turned counterclockwise until the sparking ceases. The locking handle is then tightened up again. The manufacturers recommend in general that an igniter which sparks outside should be removed and receive attention; but the above method of dealing with an igniter whose contact is worn will save time on the road. N. B.—The sparking contact must not be set too close. The points must not make permanent contact.

Short Circuit of High-tension Distributer.

Some makers of magnetos in the past have not appeared thoroughly to realize the fact that there must be very considerable wear on the working parts of these machines owing to the continued and fairly high speed at which they are run when used with gasolene motors. Trouble has sometimes been experienced in the high-tension distributers by fitting a wiper, say of hardened steel, while the contact pieces over which it rubs to cause the distribution of the high-tension current are of a softer material. These pieces are worn down, and produce fine dust over the whole surface of the high-tension distributer. This very fine metallic dust acts as an excellent short-circuiter to high-tension currents, and its presence can be readily detected by occasional misses of the explosions. This gradually becomes worse, until finally it is found practically impossible to start the engine when once it is stopped. A temporary remedy which may last from three weeks to a month is to take off the distributer cap and wipe the ebonite contacts quite clean with a very slightly oiled rag, and then replace the contact maker, when it will be found that trouble for the time ceases. This taking down of the contact piece must be done at fairly frequent intervals, and is quite unavoidable especially with the earlier forms of magneto.

Always Maintain the High-tension Circuit.

With the Bosch magneto do not make use of the safety spark gap except for an emergency. For instance, do not allow one secondary wire to remain detached from the plug when one cylinder is out of work. This puts a strain on the winding insulation, and may ultimately lead to a breakdown. Some magnetos, such as the Castle, may be connected up in exactly the same way as a battery, no special arrangement of the switch being necessary. This is the case when the contact breaker and primary coil of induction coil are in series, and not in parallel.

Wiring a Simms or Bosch Magneto to a Battery.

To employ a Simms, Bosch or similar type of magneto and also a battery and coil system with one set of sparking plugs necessitates a switch on the high-tension circuit and a considerable increase in wiring. It is best to use two independent sets of plugs, especially as the most probable cause of failure of the magneto system lies in the plugs themselves.

Setting of Low-tension Contact Points on Magnetos.

Much unnecessary trouble is experienced by users of high-tension magneto systems which have a mechanical make-and-break in the primary circuit, by failing to set the points of contact correctly. The usual error into which the uninitiated fall is that of adjusting the platinum-pointed screw too far away from the platinum point contact on the roller blade. It will be found that if the adjustment is made so close that contact is only just broken as the cam presses on the roller in its travel, the best results are obtained. About one-fiftieth of an inch is an excellent distance for all-round work. If the points are set much further apart than this, a very destructive spark takes place between the points at the moment of breaking the primary circuit. This rapidly burns away the platinum contacts, and necessitates frequent adjustment.

Setting of Sparking Plug Points.

When a magneto is used for the production of the ignition spark, care should be taken to see that the spark gaps of the sparking plugs are about half those employed with battery-provided current.

Low-tension Insulated Switches for Magnetos.

All low-tension switches of magneto machines should be insulated where they have to be handled. The insulation may take the form of an ebonite handle or a rubber tube pressed over the metallic handle. When the engine is running and it is desired to switch off, and the handle is uninsulated, if one hand is on the metal switch and the other on any metallic part of the car which is not insulated from the magneto, a terrific

shock may be experienced. In one case a serious accident very nearly occurred by this happening to a driver while steering a car. The car in question was fitted with the magneto and battery system of ignition, with a two-way switch. While running, the driver desired to switch off from the magneto on to the batteries and, owing to the switch not being insulated, the operation of switching over caused a shock to be transmitted from the magneto through the body of the driver to the steering wheel, causing him to lose control of the machine and run up the side of a bank in the road.

Replacing Magnetos Correctly.

Some magnetos are driven off one of the distribution wheel shafts by means of a coupling which consists of two tongues cut on a disk, the tongues being at right angles. One of these tongues meshes with a groove in a boss on the distribution wheel shaft, while the other meshes with a groove on the magneto shaft. Before taking down magnetos, it is always as well to mark the jaws and the tongues carefully, so that they may be inserted in the same place when putting back in position. During the time that the magneto is down, the engine crankshaft should not be rotated, because if it is it might possibly happen that the driving wheel of the magneto will receive a revolution, so that the mark again comes to the top, and, apparently, is correct for the engaging of the joint driving the magneto. Such, however, may not be the case, and the firing may take place in a totally opposite position to that which it should. Thus in trying to start up the magneto, it will be found that back firing is occasioned in the carbureter. It is always as well, after parts have been uncoupled in this manner, to check the timing before trying to start up the engine.

Setting Magneto Tappets.

A loss of power in a low-tension system magneto fired engine may often be traced to the tappet giving the "tweaker," as it is sometimes called, too much of a "tweak." The tappet lifter, which causes the electric circuit to be broken inside the

cylinder, has a definite lift, but as the tweaker is not directly connected to it, the spark may be adjusted in a manner analogous to the setting of the sparking plug points. This is done by screwing the threaded end of the tappet rod into or out of, as the case may be, the internally-screwed lifter, which is directly acted upon by the cam. The adjustment should be such that the tweaker makes a rapid jump from the insulated point, but the arc formed should not be too long, otherwise an attenuated spark is produced which has poor ignition qualities. On the other hand, if a short, quick break is given, a fine, fat, hot spark results, and the engine pulls with double the power.

Now, to adjust the tappet to produce the latter result, the engine should be turned round with the starting handle until the tappet lifter is at its highest point. Then screw down the tappet rod until there is a distance of about four millimeters between the underside of the tappet head and the tweaker. Next turn the engine until the tappet falls and hits the tweaker; this should be just before the tappet reaches its lowest point, at which it should be possible to pull the tweaker down a good way with the fingers. If a cylinder is found to be firing badly and not pulling as well as its companions, if of the multi-cylinder type, slack off the pinching screw at the head of the tappet lifter and screw up the tappet one turn; the correct movement is counter clockwise. If no better results follow, continue screwing up until nothing happens, and then start screwing down by one complete turn, for three turns, and then by half turns until the correct spark is obtained. This, of course, entails a lot of starting up of the engine; but, once found, no further adjustment should be necessary for a long period.

Incidentally, it may be mentioned that a long break at the "tweaker," in addition to causing bad firing, knocks a semicircular dent in the tweaker arm, and, again, this constant knocking wears the bearing in the ignition plate oval, and produces bad blowing and consequent loss of power.

Care of Magnetos.

The best way to keep magnetos in order is to refrain from doing anything more than is absolutely necessary to them, such, for instance, as keeping the contacts clean and free from grease, and keeping the bearings sufficiently lubricated without flooding them. If a magneto is dismembered, the permanent magnets should not be left without keepers, that is, a piece of iron or steel bar across the ends of the U magnets. If not, it will result in the loss of a certain amount of magnetism, and a consequent diminution in the power of the machine as a producer of electric current. It is only under extraordinary conditions that the removal of the magnets is necessary, and therefore practically they should never be touched.

PART III.

INDUCTION COILS.

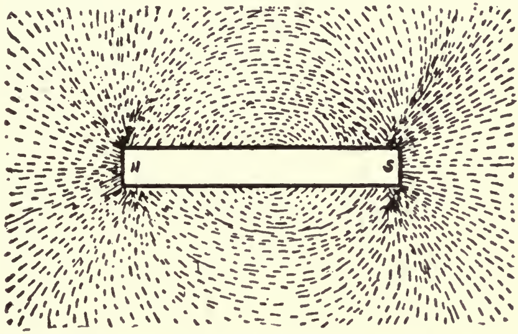
Coil—In the sense commonly employed by automobilists the term coil applies to the induction coil, the apparatus used for supplying the electric spark which ignites the cylinder charge.

The induction coil was originally invented, in something like its present form, by Ruhmkorff, but before entering into any details, it is necessary to explain the fundamental principles upon which the action of the apparatus is based, since it is impossible to explain or to understand the complete device unless these vital points are thoroughly grasped by the reader.

The automobilist who is hazy on the subject, and to whom theoretical electricity is untrodden ground, will do well to perform on his own account a few simple experiments, in order that he may comprehensively follow the function of every component part of the apparatus to his own satisfaction.

First, get a small magnet, a bar magnet preferably, but if this is unobtainable a horseshoe shape will do. Fix this magnet up in a recess in a board so that it lies flush with the surface, and lay a sheet of plain thin white paper on the top of the board, covering the magnet. Now scatter some fine iron filings on the top of the paper and tap the edge of the paper gently with a pencil or the finger, just sufficiently to

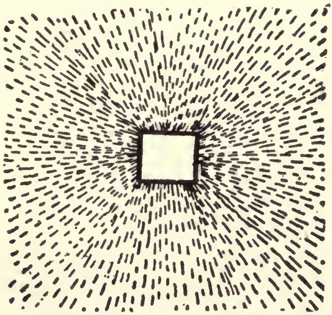
make the filings vibrate on the paper. Suppose a bar magnet to have been used, the filings will arrange themselves along



Lines of Magnetic Force in Horizontal Position.

regular lines in a curved fashion between the poles of the magnet.

Now push the magnet endways through a piece of paper, so that the paper forms a ledge of considerable width all around the magnet and at right angles to it. Repeat the scattering of the filings, and again tap the paper as before. This time the filings will be found to arrange themselves in radial



Lines of Magnetic Force in Vertical Position.

lines around the magnet, all pointing to the center. If a horseshoe magnet is employed for the experiments, circles will be found round both poles of the magnet, but congested and distorted in the space between them.

Now, let us consider what these lines indicate and prove. In order that the definite arrangement of the filings could be arrived at, it is evident that there must have been some power or force to cause such arrangement, and that this force followed the direction indicated by the filings. What happens is this: The action of a magnet, as is generally known, converts a piece of iron into a magnet, too, which is easily demonstrated by picking up a nail on a magnet and observing that the first nail will pick up a second. The magnet under consideration converts the multitude of iron filings sifted over the paper into as many little magnets, which set themselves into the positions to which they are compelled by the big magnet. The first experiment showed, therefore, that the force exerted by the magnet acted along the lines of filings obtained, the filings naturally lying along the lines in a direction coincident with the lines along which the magnetic force acted, whilst the second experiment with the single pole showed that the force emanated radially from the magnetic center.

Now, if these lines are examined they will be seen to travel in curves between the poles of the magnet in the first experiment, and these curves gradually become of such radius that they are discontinuous, and apparently proceed into space. If the combination of the two visible results obtained be considered, it will be seen that the magnet is inclosed, as it were, in a cage of these lines traveling from one pole to another.

The filings, however, are only used to make the direction of the lines visible, and to prove their existence, and, of course, there is in reality only an invisible envelope about the magnet within which an invisible force acts upon certain substances, but it has been proved that this invisible force is due to waves in the ether that space is conjectured to be full of. The term applied to the space in which the magnetic action is potent is "the field of force," and the field is supposed to be composed of myriads of "lines of force." For convenience in terminology, the first is usually spoken of as the field of the magnet.

Now, we will go a step further, and here the reader will be barred from making his own experiments, unless he has access to delicate electrical apparatus. Faraday found that if he took a coil of wire with a closed circuit (that is to say, one end connected to the other—endless) and a magnet, and he inserted the magnet sharply into the space comprising the center of the coil, an electric current was caused to flow in the coil so long as the motion of the magnet continued, and that a second current was produced, but in the opposite direction, when the magnet was withdrawn. The currents are very small, and a delicate galvanometer is necessary for their detection, but the discovery paved the way for the whole of the modern electro-dynamic machinery and induced current apparatus in use. Identical results were obtained when the coil was moved over a magnet.

We have now got a fact giving a certain amount of relationship between magnetism and electricity, namely, that motion of a magnetic field (surrounding the magnet) in the neighborhood of a coil of wire causes an electric current to pass in the wire. It was also found that a coil of wire was itself a powerful magnet when an electric current was caused to flow through it, and that as a magnet it possessed a magnetic field. Of course, each single strand of wire comprising the coil is in itself a magnet, and surrounded by its own field, so that the field of a coil may be considered to be a combination of smaller fields, and it can easily be seen that the greater the number of these small fields the more powerful their combination will be in its magnetic effect. Obviously the simplest way to increase the small fields is to increase the number of sections, or turns of wire, in the coil. The same thing applies to the coil providing the induced current.

If only a single section or turn of wire formed the coil, the current induced and the voltage of the current would be infinitesimal, but the greater the number of the turns the greater the voltage of the current produced.

Principle and Construction.

The current is produced on account of the formation of a magnetic field surrounding the wire and the section of lines of force, so that in order that the maximum power of the induced current may be attained, it is essential that the maximum number of lines of force must be cut within the active magnetic field.

One more point: The magnetic action of the coil is found to be greatly enhanced by winding it upon a soft iron core, due to the fact that this expedient collects the lines of force from the coil, as it were, and prevents them spreading further. It utilizes the lines passing through the space inside the coil, which would otherwise be useless, by absorbing them and becoming a magnet with a field of its own, thus strengthening that radiating from the coil. Both a coil of wire and soft iron, however, have the property of losing their magnetic conditions almost instantaneously directly the magnetizing influence is removed, and obviously their field of force, which is, however, as rapidly regained.

If, therefore, a coil of wire wound on a magnetic core be imagined to have the magnetizing electric current rapidly passed and interrupted, the reader will form an idea of the magnetic lines of force suddenly enveloping the coil to their fullest extent, and as suddenly vanishing again like a bladder alternately distended and allowed to collapse completely. Now, then, if this first coil be imagined as surrounded by another having a large number of turns of wire, and so arranged that the greater part of the magnetic field of the first passes through it, it will be seen that, directly the current flows in the first coil, and the field of force from it springs up, this springing up or distention of the force will cause immense numbers of lines of force to cut the numerous sections of wire as the motion proceeds, with the result that an electric current is "induced" to flow in the secondary coil, and that this continues till the magnetic field of the first coil is stationary. Directly the current ceases to flow in the first coil, the magnetic field in vanishing cuts the coils of the sec-

ond winding again and a current is induced, but which flows in an opposite direction to the first.

Thus it will be seen that the making and breaking of a continuous current in the central coil induces an "alternating current" in the outside winding.

This is precisely what happens in an induction coil, which consists essentially of a central coil of wire wound upon an iron core, called the primary winding; a second coil, consisting of very many turns of fine wire; an automatic switch for rapidly making and breaking the current supplied to the central coil, and an apparatus known as the condenser.

The engraving, Fig. 1, shows the arrangement of a hypothetical coil, so dissected that the internal parts named above can be seen.

The center A is a circular bundle of very soft iron wires, bound together and inserted in a tube, with both ends flat and projecting from either end of the tube slightly.

B is the primary winding, and is indicated by the single spiral thick black line, though of course it consists of many turns of wire in reality. The wire with which the primary coil is wound is of a good thickness and well insulated, so as to permit of a considerable flow of current at low voltage through it.

C is the secondary wire, denoted by the fine black spiral line, and this again is only shown as a single coil for the sake of simplicity. The secondary winding comprises many thousand turns of very fine insulated wire, wound in a series of layers, each layer being carefully insulated from the next, the object in obtaining so many convolutions of wire being to provide a large number of sections to be cut by the fluctuating lines of force from the central or primary coil, for, as we have seen, the greater the number of coils to be cut by these lines of force, the higher the voltage of the induced current will be, and a high voltage means a powerful spark between the points of the ignition plug.

D1 is the trembler blade of the contact breaker, which consists of a soft iron disk D attached to a flat spring, which is

fixed at its other end to the insulated terminal E. This blade or spring is free to vibrate therefore with E as its fixed point. Half-way along its length, the blade D1 carries a little disk of platinum O1, and this platinum is exactly opposite to, and in contact with, a platinum pointed screw. The platinum point is seen at O. This screw is insulated by means of the bridge F, which forms its nut, and whose feet (not seen in the figure) form terminals for the connections to it.

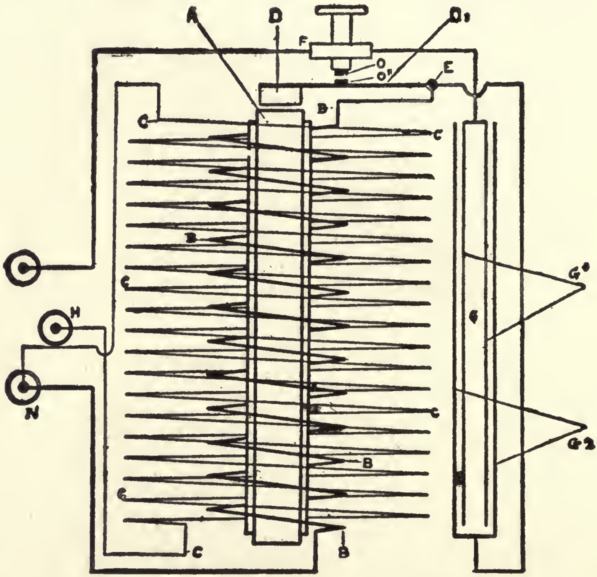


Fig. 1.—Diagram of Coil Construction, Showing Windings, Connections and Condensers.

G is a condenser, and G1 and G2 are the separate series of elements. This condenser is made of a series of sheets of tinfoil, insulated from each other by means of paper soaked in paraffin wax. The method of manufacture is somewhat as follows:

The sheets of tinfoil are cut into the form of rectangles, but smaller than the sheets of paper, so as to leave a border all round each metal sheet. One side of the rectangle is,

however, left with a tag on it in the shape of a ribbon, and in building up the condenser a sheet of paper is first laid, then a sheet of tinfoil, but placed this time so that the tag projects from the opposite end of the paper. This method is continued throughout the whole assembling of the condenser, and it is not hard to see that by this arrangement every alternate sheet of tinfoil has its tag at the same end. These tags are all connected together at either end, and wired for connection to their correct terminals.

Action of the Condenser.

The precise action of the condenser is too involved to fully explain it here, but its function generally and its particular necessity in connection with an induction coil must be stated. A condenser is essentially an apparatus for the temporary storage of current, which it is capable of refurnishing again instantaneously, its precise relation to, and the necessity for its presence among the component parts of an induction coil being as follows:

When the flow of the current is broken in the primary coil, the converging lines of force cause a strong current to flow in the secondary coil, and, as we have already seen, a coil with a current flowing through it is itself a magnet and has a separate field of force of its own. The current induced in the secondary winding is, however, itself momentary, and as this current dies away together with its field, the returning lines of force, cutting the coils of the primary winding, cause in their turn an induced current to flow in the primary coil, and the condenser is fitted in order to absorb this induced current, and to give it out again to help the current from the batteries in remagnetizing the iron core of the primary winding. The condenser also reduces the sparking at the platinum points when contact is broken, taking the induced charge, and preventing a flash, which would be produced if the circuit was broken entirely.

The three small black circles represent the terminals of the coil. P is the positive terminal, to which the positive

wire (technically called the lead) from the battery is connected, N is the negative terminal, and H is the high tension terminal, to which the heavily-insulated wire to the spark plug is attached.

Thus, to trace the condenser circuit, the current from the battery originally passes from P to F, thence through the platinum points O and O1 to E, through the coil B B B, and back again to the battery through N. In doing this, two things happen: First, the central soft iron core A becomes magnetized, and second, an induced current is caused to flow in the secondary coil C C C.

The magnetization of the core A, however, causes the iron head D on the trembler blade D1 to be attracted to A, and thus break the primary current. Directly, however, this current is broken, the field about the coil B, which, in spreading caused the induced current in coil C, almost instantaneously collapses. In doing so, it causes a second and stronger and induced current to flow in C, but in the opposite direction, and further, induces a current in the coil B, also in the opposite direction to the former current in the battery.

The condenser is connected as a shunt (see page 36) across the ends of the primary circuit, by its separate sets of leaves being attached at E and F. When the primary current is broken and an induced current is suddenly set up, the condenser takes this induced current, which is discharged into the condenser (like a Leyden jar), which then contains a "static charge." When the points O, O1 come into contact, this charge is discharged again, and assists the remagnetization of the core.

Figures 2 and 3 show an actual French coil in sectional plan and elevation, and after the above description, it will be sufficient to enumerate the various constructional parts.

A is the central soft iron core, made of many straight lengths of iron wire, and bound together by the insulating tube J. I is the primary coil, consisting of turns of insulated wire of about 16-gauge, wound in several layers, each layer being separated from the next by an interposed sheet of pa-

per soaked in paraffin wax. This primary coil is cased in a second ebonite tube J, and the secondary coil 2 surrounds it. This coil is constituted in the same way as the first, but involves many thousand turns of very fine wire, 36, 38, or 40 gauge, having double silk wound insulation. More care is taken also in insulating each layer from the next.

The composite coil is placed in one compartment of a rectangular box, and the condenser H in a second, the cover being formed by an insulatory plate J. G is the fixed end of the trembler blade, of which B is the soft iron head. The

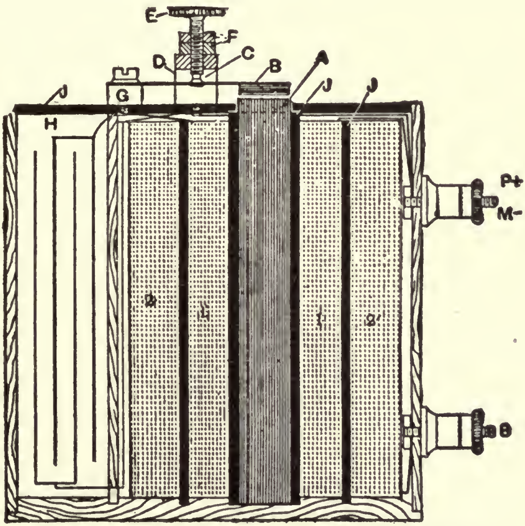


Fig. 2.—Section of French Coil in Elevation.

contact points are indicated by C, and the bridge D carries the trembler adjustment screw E, and the lock nuts F, F.

The condenser H is connected between the pillar at G and the bridge D inside the casing.

There are three terminals P, M, B to the case illustrated, indicating positive, P; negative, M; plug, B. The initials are those of the French words "pile," battery; "masse," earth, and "bougie," plug, respectively, and are the letters commonly found on French coils. In the elevation, P and M fall

one behind the other, and only one is capable of being shown. P is connected to the bridge D inside the casing, one end of the primary coil goes to M, and the other to G. The high tension coil has one end attached to B, and the other to M. These connections can be plainly seen in the plan, but are somewhat difficult to trace in the elevation.

The terminal P is always connected with the battery lead, and B with the sparking plug, but the terminal M is connected with some metallic part of the frame which acts as a return path both for the low tension current to the battery, and for the high tension current from the plug.

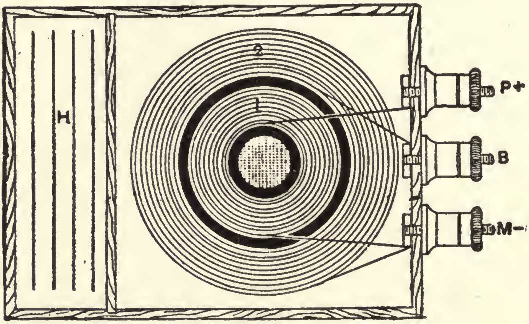


Fig. 3.—Section of French Coil in Plan.

Thus even supposing there to be four coils in one case, one end of each of the primary coils would go to a single terminal, and one end of each of the high tension coils would go to the same terminal, so that a single "lead" from this central binding screw would do all the "earthing" required.

Coils are sometimes made in divided sections but this type is not so common on automobiles.

PART IV.

TIMING IGNITION.

Timing—The regulation of the ignition in an internal combustion engine; the regulation of parts of machinery so as to secure proper co-ordination.

Before studying the article below the reader is advised to peruse and study thoroughly the article on "Ignition," which will enable him to grasp more fully the methods and the effect of timing as dealt with here. Absolutely correct timing both of the ignition and the valve mechanism is essential if the engine is to give its full power. As regards the ignition, a serious irregularity may cause great injury through the spark occurring too early or not being synchronized in the various cylinders, and so setting up a "knock" which may injure the bearings and even break the connecting rod or crank shaft. We shall deal first with the coil and battery high tension system.

The first point is to determine exactly the point at which the ignition should take place. It must be understood that by the word "ignition" is meant the firing and expansion, or, in simpler words, the explosion of the gas charge, and not the time of the spark itself. There is a distinct difference between the time at which the spark passes across the points of the sparking plug and the time at which the charge begins to expand.

To insure the greatest efficiency, the gas charge should begin to expand immediately the piston begins to descend, that is, theoretically, at the point where the piston comes to rest. As there is an appreciable interval of time between the time of breaking contact and the ignition of the gas, it follows that the break of contact must occur just that space

of time ahead of the time when the piston comes to rest at the top of its stroke.

This time interval is exceedingly small, but we can readily measure it by distance, because the travel of the piston in the cylinder is at such a velocity that the piston moves an appreciable distance in a length of time which is hardly appreciable or capable of measurement for practical purposes.

It may be stated that for an engine running at 1,000 revolutions per minute, with a stroke of 4½ inches, and with the ordinary 4-volt battery, the spark should take place when the piston has about five-eighths of an inch to travel to the top of its stroke. That may be stated as a general truth, but so many circumstances occur to alter the conditions that it cannot be relied upon as theoretically correct, because the amount of compression, the density of the gas charge, and the state of the insulation in the coil will all affect the question.

Marking the Flywheel—To find the correct firing point, it is necessary to locate the exact position of the flywheel when the pistons in their respective cylinders are at the highest point in the firing stroke. In many cars the dead center points and the correct firing points are both marked on the periphery of the flywheel. Failing such marking, get an index pointer fixed to the dashboard, pointing to the top of the periphery of the flywheel, as in the diagram which follows. It can be made out of sheet tin. Next open the compression cocks, and, taking each cylinder in turn and beginning at the one which fires first, push an ordinary bicycle spoke through the cock until it rests on the piston head. Then turn the starting handle until, at the end of the compression stroke, the spoke rises to the maximum height, which, of course, indicates the highest point which the piston reaches in the cylinder. This should be carefully checked by holding the spoke in one hand, and with the other gently moving the flywheel backward and forward or operating the starting handle until satisfied that the highest point has been found. Then put a file mark on the flywheel at D 1 exactly

opposite the spot toward which the index finger points, and also nick the spoke with a knife blade held flush across the top of the compression cock. Follow the same operation with the other cylinder or cylinders, and mark the flywheel again, but with a different sign or number, to distinguish it from the first mark. A very slight difference in the height of the spoke will be exaggerated in distance along the flywheel between the two marks, so that one measurement will check the other. A separate spoke should be used for each cylinder and marked for identification. This is advisable, because it often happens, through bad fitting or because the compression cocks are not all the same height, that the distance between the top of the piston and the top of the compression cock would not be the same in one cylinder as in the other, and if one spoke were used for all confusion would result.

To Find the Dead Center—For the benefit of the beginner, we may explain more definitely how to locate the position of the piston at the dead center when it has completed the compression stroke and is about to begin the firing stroke. The following is the simplest method.

After having dropped the spoke through the compression cock, turn the starting handle until the exhaust valve is observed to open. The piston will then be about to ascend on the exhaust stroke. As the flywheel is still turned, the piston, and with it the spoke, will descend on the suction stroke, and having got to the lowest point will ascend again on the compression stroke. It is from the highest point of this stroke that the timing is calculated, for when the dead center is crossed the firing stroke commences. The correct distance of the piston from the dead center when contact is broken is technically known as the "lead." This depends on the lag in the coil, the size of the engine, and the speed at which it is run, consequently an advance and retard arrangement is fitted to enable the driver to alter the timing to suit the variation in speed.

To Find the Piston "Lead"—Having found the dead center, the next operation is to locate the piston "lead"—in other words, the correct position of the piston in the cylinder when the spark lever is fully advanced. As we have already pointed out, a fair average "lead" is about ⅝ inch, and if the exact "lead" of the engine being dealt with cannot be obtained from the makers, this "lead" might be tried experimentally. With this object in view, nick the spoke exactly ⅝ inch above the dead center mark already recorded on the spoke applying to the particular cylinder under consideration. It is convenient for the purpose of seeing the mark better to black the top half of the spoke as far as the mark that denotes the lead, and leave the lower half bright. It will then be easy to distinguish at once when the piston has risen to the firing point. Having duly marked the firing point on the spoke, turn the flywheel until the index points to the dead center mark D 1 of the particular cylinder being dealt with, when the piston in this cylinder is at the top of the compression stroke. Next place the spoke through the compression cock of this cylinder, and turn the flywheel backward until the higher, or firing, nick on the spoke is just level with the top of the compression cock, and mark the flywheel at the spot F 1 to which the index then points. This will permanently locate the "lead" on the flywheel corresponding to the piston lead as marked on the spoke. The other cylinders should be similarly dealt with as indicated in the diagram; each with its own spoke.

In cases where there is no opening into the top of the cylinder through which the measuring wire or spoke can be inserted, it will be necessary to determine the piston position from underneath instead of above. For this purpose it is necessary to drill a small hole in the bottom of the crank chamber underneath each cylinder. These holes should all be drilled slightly to one side of the center line of the crank case. If when viewed from the front of the engine the flywheel rotates in a clockwise direction the holes should be drilled about an inch to the right of the center. If the

flywheel revolves anti-clockwise, then the holes should be drilled one inch to the left of the center. These holes should be tapped with a screw thread, and screws fitted to close them after use and prevent leakage of the lubricant.

A long spoke can be passed up through these holes into the under side of the piston and the highest point deter-

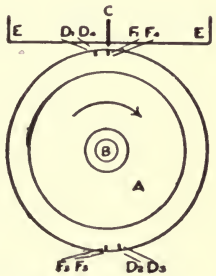


FIG. 1.

FLYWHEEL INDEX FOR FOUR-CYLINDER ENGINE.

In which the sequence of firing is 1, 2, 4, 3, beginning from the dashboard end, and in which the flywheel revolves clockwise, when looked at from the rear end. This is the case with some few engines, such as the Peugeot and Coventry Humber, but not with the majority, in which the flywheel revolves in the opposite direction.

A, Flywheel.

B, Crankshaft.

C, Index pointer fixed to dashboard.

D1, Mark on flywheel which, when exactly under index, indicates dead center point at commencement of firing stroke of first cylinder, counting from dashboard end.

D2, Dead center mark of piston for firing stroke of second cylinder.

D3, Dead center mark for cylinder firing fourth.

D4, Dead center mark for cylinder firing third.

E, E, Dashboard.

F1, Mark on flywheel, which should be exactly under index, when the spark occurs on firing stroke of No. 1 cylinder counted from dashboard. This, in the case of coil and battery system, happens when the wiper of the contact maker makes contact, and in magneto ignition at the moment when contact is broken.

F2, Index mark for timing spark in the cylinder which fires second. (Second from dashboard.)

F3, Index mark for cylinder firing fourth (third from dashboard).

F4, Index mark for cylinder firing third (fourth from dashboard).

TWO-CYLINDER ENGINES.

In the case of two-cylinder engines the flywheel marking will depend on the setting of the crankshafts. Where the cranks are set at 180 degrees the marking will be similar to that for the first two cylinders of a four-cylinder engine, that is to say, D1 and D2, with their respective F1 and F2, will be on opposite sides of the flywheel. Where the crank pins are in line with one another D1 and D2 will coincide as also will F1 and F2, but care must be taken in this setting not to confuse the exhaust stroke with the compression stroke as noted later. The latter arrangement of the crank pins is now seldom adopted.

mined and marked on the spoke. The distance of the "lead" required is then marked on the spoke above the first mark and the flywheel turned until this mark comes opposite the edge of the crank case. The dead center and "lead" are marked on the flywheel rim as described before. In this case,

as in the other, it is necessary to use a separate spoke for each cylinder.

As an example of how flywheels are marked by the manufacturers, we may refer to the marks on the 20 H. P. Unic flywheel. It must be distinctly understood that these marks will not be the same on other engines. It is necessary that a pointer should be arranged, preferably fixed to some part

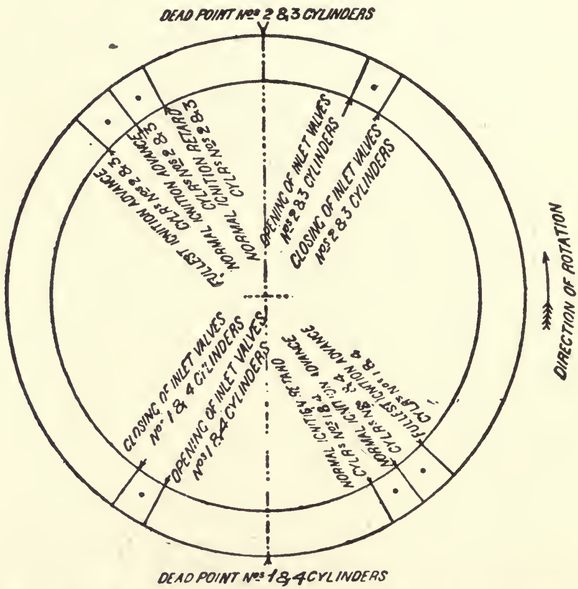


FIG. 2.—TIMING DIAGRAM OF A 20 H.P. FOUR-CYLINDERED UNIC ENGINE.

of the chassis frame, and not to the body, and in such a position as to denote the dead center when the cranks are vertical. This marking is for a four-cylindered engine and sufficiently explains itself; but motorists are advised when they receive delivery of a motor vehicle or chassis to get a diagram marked out in the same way as the one illustrated to show at which times the inlet and exhaust valves of the different cylinders should open and close, and at which time

the ignition should take place when the ignition is fully advanced, and also to see that their flywheels are so marked from dead center (to be ascertained by the spoke test). They will then be easily able to confirm or adjust their ignition and valve timing.

To Check and Correct the Piston "Lead"—If the flywheel has been already marked, but the motorist is doubtful as to the correctness of the firing, he should proceed as follows:

Turn the flywheel until at the end of the compression stroke the position of the testing spoke indicates the dead center. If the dashboard index then points to the mark on the flywheel he will know that, so far as the dead center is concerned, the markings are correct. Next measure off the correct piston "lead" on the spoke and check in a similar manner the corresponding mark on the flywheel. If the markings are incorrect, the flywheel should be re-marked.

Having now got the correct piston "lead" duly located, take the cover off the contact maker and close the circuit, seeing that the batteries are fully charged and that the plugs give a good fat spark. If the ignition is by means of a trembler coil the buzz of the trembler will indicate the time when the spark takes place, and the bright part of the spoke will be observed commencing to emerge above the cylinder head. Now, if everything is in order and the spark is advanced to the full, the buzz of the trembler or the spark on the plug ends will take place exactly as the bright part of the spoke appears. They should not occur before, otherwise premature firing will take place, causing considerably more loss of power than the same amount of late firing.

A note should be taken of the blade or wiper which connects up to each cylinder, and it should be marked with the number of the cylinder to which it opens electric communication.

The fiber plate on which the wipe contact maker is mounted, and which moves round to advance or retard the ignition, should be put forward as far as possible so that the ignition lever on the steering column will not be capable of being

moved any farther. The stop should, of course, be, and generally is, on the fiber block. Now turn the crank shaft and mark carefully the point at which each cylinder fires.

The timing may be altered by pushing forward or pulling back the blades of the wiper, so that the cam or contact disk fiber segment on the two-to-one shaft meets them earlier or later, as the case may be. As a rule, it will be found to meet them late, and by filing the two holes in the blades by which they are attached to the insulated blocks on the fiber plate

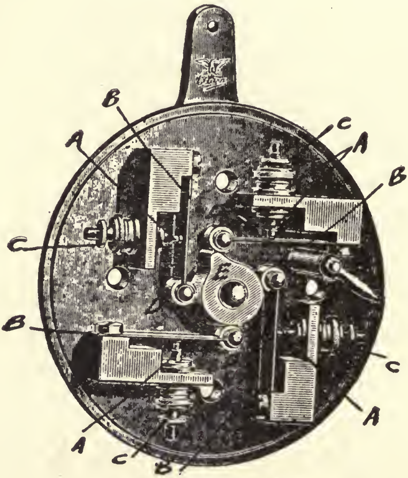


FIG. 3.—CONTACT MAKER.

they may be adjusted nearer or farther away from the cam, or from the contact segment let into the revolving disk, whichever type is used. They must be nearer to the cam as it comes round if the firing is late, and farther away if it is early.

It will not often be found that these wipers or blades wear unevenly, but if they do, that is the procedure. When all fire exactly as the piston reaches the predetermined point, the timing of the ignition, as far as the relative timing of the four, three or two cylinders is concerned, is correct.

In the case of a contact maker, as in Fig. 3, where a cam lifts blades which make contact with platinum pointed screws A, the blades B having platinum pieces on them, the adjustment is, of course, made by the platinum contact screws. Before making the adjustment all the platinum contact pieces on the blades and all the ends of the contact screws should be cleaned, and, if necessary, filed square across, so that the two pieces of platinum meet flat with each other.

In this type the adjustment is made by screwing the contact screw nearer the blade if the firing is too late, and screwing it farther away if the firing is too early. In each case care should be taken to see that the screws are set fast again by the lock nuts C or any equivalent device.

This is, of course, a very minute adjustment, and once made it should not be altered unless absolutely necessary.

Sometimes the length of the spring blade B carrying the roller D at its end varies from that of its neighbors. If it is too long the cam E will catch and raise it early, while if it is too short the cam may not catch it until too late. This may be remedied by filing the holes in the blade oval, as we have described in a previous case, and moving the spring blade nearer or farther away from the cam as may be required, but when this adjustment is made it is still necessary to adjust the platinum contact screw until the spark takes place at the determined time as indicated by the measuring spoke.

Other types of contact makers, and there are many of them, must be treated in the same way. They have all provision for adjustment, so that the driver may set the different contact points to meet early or late as the case may demand, but whatever the system employed the contact must be made, in the case of the trembler coil, or broken in the case of the make-and-break system, at a predetermined time in the case of each cylinder, and that time is taken from the position of the piston in the cylinder.

What we have said so far refers only, of course, to the correct timing of the different cylinders in relation to each other. Having accomplished the foregoing, any other defects in the

timing of the spark which may occur through lost motion in the camshafts or the gear wheels which drive the two-to-one shaft, or in the rocking of the fiber plate on its support, or any looseness between the rods which connect the advance spark lever to the fiber plate, or any defect in the coil, will affect all cylinders equally.

Having then got all the cylinders in tune, we may proceed to rectify some other defects which may cause loss of power in this system. These defects, so far as timing goes, will cause loss of power in all cylinders equally, but any endeavor to remedy them before seeing to the timing as between contact maker and cylinder would lead to inevitable confusion.

Timing the Coil or Coils.—It has been pointed out that in timing the ignition of the various cylinders in the system which makes use of the coil and battery, it is necessary that the contact maker should make or break contact at the same relative time in all cylinders, and that so long as the same relative time is kept in all cylinders, we may depend on other means for timing the spark in all cylinders to take place at just the time when it will give the best results.

It is essential in this connection to differentiate between those systems using a separate coil for each cylinder and those using a single coil for all cylinders. It is of the former system we have so far been speaking.

Where a coil is fitted for each cylinder it is, of course, necessary to see that the time adjustment of the trembler on the coil is correct. It is not so necessary to have a high rate of vibration of the trembler in this case, but it is necessary that the trembler on the coil should respond at once as soon as the contact maker opens up the connection with the primary circuit.

If there is any appreciable lag between the making of contact by the contact maker and the buzzing of the coil to which it is attached it may be through the trembler blade of the coil being adjusted too far away from the central soft wire core of the coil, and the remedy is to set the blade so that it is normally nearer the core, and yet not too much pressed

upon by the contact screw. As a general rule the trembler blade should rest one-eighth of an inch, and not more, away from the end of the core of the coil. When in this position it should just make contact with the contact screw, and when one-sixteenth of an inch away from the core of the coil it should break contact. The speed of vibration is dependent on the length of the trembler blade and its caliber, and this cannot well be adjusted by the user. These measurements are only approximate.

If the trembler blade is adjusted too far away from the core and bears too heavily against the contact screw, some appreciable length of time may elapse before the primary current induces sufficient magnetic pull in the core to pull the trembler for the first time toward it, and it must be remembered that it is only when the trembler breaks contact with the contact screw that the first spark passes across the sparking plug points.

It is necessary, therefore, to see that all the trembler blades on the different coils act as quickly as possible, and as nearly as possible with the same interval of time after the making of contact. This can be easily tested by attaching a piece of wire to the metal segment in the contact maker (in the case of a wipe contact) and touching in turn each of the wipers, noting by ear the quickness or slowness of the trembler to respond to the contact. The ear alone can be relied upon for this adjustment, and each trembler should be adjusted so that it responds to the contact as quickly as, and not more quickly than, its neighbor.

When making this adjustment it is advisable that the coils and batteries should be in position in the car. The indicating marks which it is advisable to put on the different contact making blades should refer to the coils equally with the cylinders, so that the coils may be identified in sets with the cylinders they fire and the contact makers which operate them.

When making this adjustment with the style of contact maker which uses a cam and raises a spring blade which

makes contact with a contact screw, we can discard the wire connection and simply with the fingers press the blades into contact, listening at the same time for the buzz of the coil.

It ought to be mentioned here that sluggish working of the trembler on the coil may be caused by other circumstances than the wrong adjustments of the trembler blade. It may, of course, be due to weakness in the battery, but in this case, under ordinary wiring systems, all coils would be served alike, and the lagging or sluggish working of the tremblers would be common to all.

The remedy for this is sufficiently obvious—the battery needs recharging—but it is not a defect which will interfere with the relative timing of the cylinders, which is the immediate matter we have in hand.

Another cause of sluggishness of the trembler on the coil is the tendency of the iron core of the coil to become more or less permanently magnetized so that it does not immediately become demagnetized as soon as the primary current is shut off by the breaking of contact. This results in the trembler being held too long from the contact point or screw, and so preventing contact being made again at once.

In mild cases of this trouble a remedy is to be found in pasting over the end of the core of the coil a disk of thin paper, so that the trembler can never get into close contact with it. This is only a remedy which can be successfully applied in mild cases; the real remedy lies in a new core or taking out the old core and annealing it. It is because the iron wire of the core is not sufficiently soft that it retains its magnetism too long after the exciting current has ceased. The softer the iron wire of which the core is built the sooner will it become magnetized under the influence of the primary current, and the sooner will it become demagnetized when the current ceases—the very properties we want in the highest degree in the case of an induction coil.

It may be remarked here that it is often possible to restore the softness of the cores by annealing them in a clear red fire and allowing them to cool evenly and gradually in hot

ashes. It is not advisable, however, for the motorist to interfere with the coil at all, with the exception of the adjustment of the trembler.

Sometimes a coil trembler will prove sluggish owing to a short circuit somewhere in the winding—generally in the low tension or primary wire. Such short circuit is generally caused by loading the coil with a current of too great a voltage, which may happen through two or more batteries being coupled up in series instead of in parallel. This primary current induces one of so much higher tension that it may heat the wires until the insulation is destroyed, when two adjacent windings may come into contact with each other and a short circuit occur. Such troubles can only be remedied by rewinding the coil—a task quite impossible for the amateur. When coils are damaged in this way they should be returned to the makers, and often it will cost nearly as much to rewind one as the purchase of a new coil.

It should be thoroughly understood that for the purpose of timing the coils it is not advisable to meddle with anything other than the adjustment of the trembler blade, and that any defect in the coil can only be remedied by a new coil or the repair of the old coil by a competent repairer. What is essential is to get the first make-and-break of the trembler of the coil to take place immediately the contact is made by the contact maker, and if this has been adjusted in accordance with the instructions already given, then all the cylinders will fire at the same time relatively to their piston stroke and to each other.

Synchronized Ignition using a Single Coil.—This question of the timing of coil tremblers is so important that most firms now use synchronized ignition. The Napier is an instance of this. The usual contact maker is fitted, making as many contacts per two revolutions of the engine as there are cylinders to be fired. This contact maker opens up, each time, communication through the primary winding of a single trembler coil, so that on each piston coming into the firing position a

series of sparks will pass across all the sparking plugs, which are all in circuit in the high tension windings of the coil.

Now, in order to utilize but one sparking plug at a time, and only that which fires the cylinder which for the time being is ready to be fired, it is necessary to supply a distributer in the high tension circuit. This distributer is another form of wipe contact maker, only that instead of dealing with the primary or low tension current it deals with the high tension current, and that from only one coil; an intermittent current being delivered through the trembler make-and-break. This system gets over all the trouble of synchronizing the several coils so as to give equal timing in all cylinders, and is being very generally adopted, not only with battery ignition, but also with high tension magneto ignition. The distributer, once set, will fire all cylinders at exactly the right time, and will prevent any loss of power through incorrect timing or sparking of the cylinders relatively to each other. The Napier system is illustrated under Ignition.

The Most Effective Firing Point.—We have described how to get all cylinders synchronized, so that they will all fire at the same point in their piston travel. It now remains to determine the exact time at which the ignition should take place in all the cylinders in order to get the highest power out of the fuel used.

This point of ignition depends to a great extent on other and extraneous circumstances. When running the engine at a very high speed it is found that the piston travels so fast that the limit of time allowed for the ignition of the charge and for the current to pass through the primary winding, excite the secondary current and start the trembler vibrating, is so very small that the ignition has to take place some distance before the piston reaches the top of the compression stroke. The speed of the engine, the nature of the gas mixture, and the length of stroke compared with bore, as well as the amount of compression obtained, and the intensity of the spark, are all factors in fixing the earliest point at which the ignition should take place.

As a general rule, it may be said that the make or break of the current—as the case may be—should take place when, with ignition fully advanced, the piston is about five-eighths of an inch from the top of its stroke. As a matter of actual fact, when the engine is running fast, with this allowance for piston lead, ignition of the charge takes place on the dead point which is the desideratum for efficient combustion.

It will be understood that when the sparking is advanced too much the charge will be fired on the top of the up-coming piston, which will cause a tremendous knock in the engine, easily heard, and sometimes felt by the experienced driver. When starting, of course, the ignition is always retarded, because the engine is then running so slowly that there is ample time for the spark to be produced after the contact maker has connected up the primary circuit.

Some manufacturers arrange for the advance and retard of the contact maker being varied by the driver within very wide limits, and thus leave it open for him to advance the spark to such an extent as will cause knock, due to premature or back firing. Though the engine cannot actually be reversed when running at high speed with the full load of the car on it, a most dangerous strain may be put on the engine mechanism and the transmission system generally.

It is advisable, therefore, to arrange so that when the position of the sparking lever on the steering wheel is determined, the engine shall be running at its maximum speed, it shall have a full load on, and shall be taking the best possible mixture. These conditions are only to be obtained in actual running on the road, unless the user has some means of applying a load by means of a brake on the engine flywheel. The best way, therefore, is to get the car running on a long, straight stretch of road, preferably with a very slight down gradient, put in the top speed with the accelerator in action, if one is fitted, and then gradually advance the ignition, carefully listening to the engine. The moment the slightest sign of a knock is noticed it can be taken for granted that the ignition has been advanced too far and is taking place too early. The

lever should then be moved back very slightly, so as to stop the knocking, and with the car traveling at full speed, and the engine working quite smoothly, the position of the spark lever can be noted for future reference. It should be understood that the position of this lever on the steering column, relatively to the position of the contact maker plate, can only be altered by some alteration in the joints or in the rods which convey the motion from it to the contact maker plate. It is advisable that it be so adjusted that the lever cannot be operated too far, or farther than necessary to advance the ignition without causing it to take place too early. In most cases the stop is on the plate of the contact maker, but in all cases it should be so adjusted that the lever cannot be moved too far.

If this adjustment is properly made, the driver will be able to get the highest power out of his engine, but, of course, the spark should always be retarded when starting, when the engine is running slowly, or when it is laboring on a hill. The latter for the reason that when the engine begins to labor and run slow, if the ignition is not retarded it may possibly fire on the upcoming piston and cause a "knock" and its resulting strains. As soon, however, as a change of gear is effected, the ignition should be again advanced.

Timing the Valves.

We shall now deal with the timing of the valves in an internal combustion engine, and some defects which may cause loss of power. Generally speaking, not much can go wrong with the engine to put the valves out of time. The most usual defect is due to wear, and this wear may occur in a number of places and cause combined errors which will make one big error sufficient to put the valves out of time. For instance, suppose that the cams on the valve shaft and the ends of the tappet rods or valve plungers were to wear excessively, then the lift of the valve would be sensibly diminished. The same defect would result if, through the constant

hammering of the plunger or tappet rod, the end of the valve spindle were slightly flattened out, or the end of the plunger. Both these defects will cause the valve not only to lift too late, but also to close too early, and will also result in the valve not opening high enough to give the full area for the gas to flow through. These remarks apply equally to the inlet valves, where these are mechanically operated, and in this case the defect would probably cause more loss of power than the same amount of wear in the exhaust valve mechanism. The surest way to detect excessive wear in these parts is to examine the space which exists between the bottom of the valve stem and the top of the plunger rod or tappet rod. When the valve is down on its seat and the shaft is turned so that the plunger is on the lowest part of the cam, there should be sufficient space to insert an ordinary visiting card, and not more. Too much space here shows wear, and too much space also sets up excessive hammering between the plunger and the valve stem, beating the metal down and aggravating the trouble.

This defect may be remedied in modern motor cars by readjusting the adjustable plungers, so that when the valve is on its seat there is just the thickness of a visiting card between the bottom of its stem and the top of the plunger when the engine is hot. If the plungers are not adjustable, it may become necessary to alter the length between the valve face and the bottom of the valve stem, which can be done by turning the valve head in the lathe.

Other causes of improper timing of the valves may be radical injury to or misplacement of the gears which transmit the motion from the engine crankshaft to the camshaft. If there is excessive wear on the teeth of the gear wheels, or if any of the wheels get loose on their shafts through any cause, then a certain amount of backlash or lost motion is set up, and this makes the whole of the operations of the cams slightly later than they ought to be in relation to the position of the piston in the cylinder. These defects cannot be remedied by

the user except, perhaps, in the case of loose keys, when the obvious remedy is to take out the keys and fit new ones. This, however, is an expert fitter's job, and wants careful doing, as the wear in the key-ways will necessitate the latter being enlarged and bigger keys fitted. Wear on the teeth, which in good engines can only take place after much use, can only be remedied by a new pinion or gear wheel. With big gear wheels, such as are now fitted on all high class cars, the amount of wear which would take place would make an almost inappreciable difference to the timing, as the amount of movement on the camshaft would be so very slight.

In case of an accident, such as a broken crankshaft, the camshaft may get twisted round, and this might result in one set of cams being later or earlier than the other, as the case may be.

Sometimes, when a car has been dismantled, and the engine taken down for any repair, it happens that the parts are reassembled with the wheels meshing with each other in the wrong teeth. In every pair of gears a tooth in one wheel and a space between two teeth in the other should be marked with a center punch, and this should be done as soon as it is found that the timing is correct. If the user, for any purpose, disengages these gears, he should see beforehand that two such marks exist. If they do not, he should himself make them before he takes the gears apart from each other, marking them on the sides of the teeth, so that the marks come exactly together; one on the tooth and one against the space is the best way.

The cams operating the valve plungers are generally in one piece with the camshaft, being machined out of solid steel. There is thus no possibility of loss of power owing to their getting shifted round on the shaft.

Where automatic inlet valves are used, there is no mechanical timing for them. Nevertheless, the time at which they open can be regulated by the adjustment of the springs which keep them normally on their seats. The stronger the tension on this spring the later will the valve open, for the piston

will have to descend appreciably before the difference in pressure between the gas inside the cylinder and the atmosphere outside it is sufficient to open the valve. As long as the tension on this spring is sufficient to keep the valve closed, and to close it quickly on the commencement of the compression stroke, that is all that is required. Any pressure above that which is necessary for this purpose will cause loss of power. Automatically operated valves will now only be found in motorcycle engines or in examples of the earlier cars.

The timing of the exhaust valves may be affected by weak springs. When these get weakened through heat, or through fatigue, they should be at once renewed.

In the full-page diagram herewith we have given the average lead for the inlet and exhaust valves, calculated from a number of well-known engines. These cannot, of course, be taken as absolutely correct for any particular engine, but it may be taken for granted that if the user does not know actually the timing adopted by the manufacturer, and he times his engine according to this diagram, he will get good average results.

The actual timing of the engine in the well-known Mercedes car may be given as an example. It is as follows:

Inlet Valve Opens—When piston has traveled 1 mm. after the closing of exhaust valve.

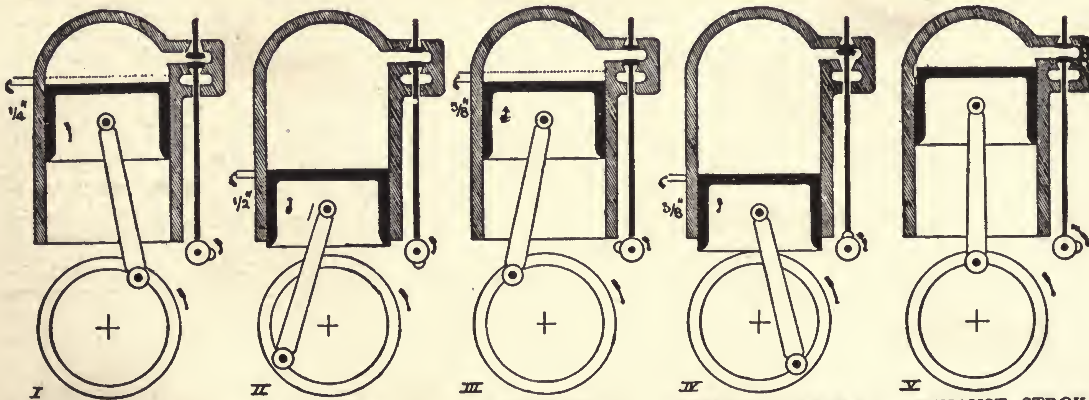
Inlet Valve Closes—When piston has turned dead center from bottom of suction stroke.

Exhaust Valve Opens—When piston is 25 mm. from the bottom on power stroke.

Exhaust Valve Closes—When the piston is just over the dead center at beginning of suction stroke.

Magneto Ignition—Low Tension System.

In the low tension system of magneto ignition the "lead" should be much less than when the spark is produced by coil and battery, because in the first place the spark occurs prac-



SUCTION STROKE. Inlet valve *opens* ¼in. *after* piston has started to descend.

COMPRESSION STROKE. Inlet valve *closes* ½in. *after* piston has commenced to ascend.

COMPRESSION STROKE Spark contact is made ⅜in. *before* piston has reached dead center, with ignition fully advanced, after which downward power stroke takes place.

EXHAUST STROKE. Exhaust valve *opens* ⅜ in. *before* piston commences to ascend.

EXHAUST STROKE. Exhaust valve *closes* when piston has reached the dead center.

The dotted lines in all cases denote the dead center at each end of the stroke.

The times of opening and closing the inlet valves only refer to those valves which are mechanically operated.

In this diagram the positions of the piston are shown at the time when the inlet valve opens, when it closes, when the sparking should take place, the exhaust valve opens, and when it closes. Different makers adopt different timings, but above is about the average of 14 well-known makers.

The timing of the spark contact refers only to high tension ignition. When the contact is broken inside the cylinder, as in the low tension magneto system, it should be broken almost immediately on the dead center.

N.B.—This diagram shows automatically operated inlet valves. The timing will be the same with mechanically operated inlet valves.

tically instantaneously with the break of contact in the cylinder, there being no induction coil to produce a "lag," and in the second place the spark is more in the nature of a flame,

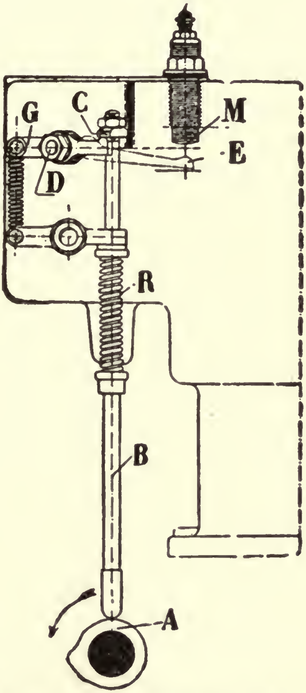


FIG. 5.—THE PEUGEOT CONTACT-BREAKING MECHANISM.

A, Cam or valve shaft actuating tappet rod B.
B, Tappet rod; sometimes called the Trip Rod.
C, Interrupter Catch; sometimes called the Tappet.
D, Rocking lever shaft.
E, Contact arm inside the cylinder; sometimes called the Interrupter.
G, Arm of striker, to which spring is attached. The other arm against which C acts is generally referred to as the Striker, or the Interrupter Arm.
M, Igniter plug inside cylinder; sometimes called the Insulated Pin.
R, Spring for keeping B in firm contact with A.

and hence produces more rapid and more complete combustion. In fact, in some types of engines there is no "lead" given, the spark occurring when the piston is at the dead center after the compression stroke. A very slight difference in

the time at which the break occurs in the various cylinders will cause considerable variation in sparking, with consequent loss of power and balance, and to get the correct adjustment, therefore, is a delicate operation.

Before proceeding further, we should recommend the reader to carefully study the illustration of a simple make-and-break system under Ignition, with the descriptive matter relating thereto, and also the illustration of the F. I. A. T. system in the same article.

There are variations in detail among the different systems, but the principle is the same. Consequently, if we take for our purpose the mechanism as fitted to the Peugeot engine it will prove a sufficient guide to the intelligent reader, even if the system he is using may differ slightly.

In Fig. 5 it will be noticed that the interrupter catch or stop C is on the top of the tappet rod B. The action is as follows: The cam A, which is fixed on the half-speed shaft, acts on the lower end of the tappet rod B. This rod is normally kept in contact with A by means of the spring R. As long as the rod B is in contact with the circular portion of A, the interrupter catch or stop C pressing against one arm of the striker G keeps the contact arm E, which is inside the cylinder, and is consequently shown in dotted lines, from contact with the igniter plug M. When, however, the projecting part of the cam A raises the tappet rod B the interrupter catch or stop C is raised off the end of the small arm of the striker G. The action of the spring on the other arm of G then brings the end of the contact lever E in contact with M. The circuit is then completed, and when the tappet rod B suddenly leaves the projection on the cam the break thus caused in the circuit between E and M produces the spark, which ignites the charge.

Now, wear may take place at the following points, but more especially the last three: The cam A, the lower end of the tappet rod B, the interrupter catch C, the end of the striker against which it bears, the contact lever E, and the igniter plug M. This wear will alter the exact period at which

the contact between the contact lever and the igniter plug is broken, and so affect the timing.

An engine such as the two-cylinder 10-12 H. P. Peugeot gives its best results at about 850 revolutions per minute, and consequently it requires a very slight "lead." After careful experimenting on a pattern in which no provision was made for advancing the ignition, it was found that a 1-64 inch lead gave smooth running, and on trying the car on a test hill it took five adults up on the high speed, which surpassed its best performance when new. In most cars, however, the break of contact between arm and igniter plug should, with the ignition advanced, be timed to take place considerably earlier.

We will now suppose that the reader has a similar car to the 10-12 H. P. Peugeot, which is of typical construction, and wishes to adjust the timing for a lead of 1-64 inch, or, in other words, regulate the break of contact in each cylinder to take place when the piston is within 1-64 inch of the highest point on the compression stroke. The following is the modus operandi:

Having located the position of the piston at the dead center, as already described in connection with the coil and battery system, measure off 1-64 inch above the dead center point on the spoke, and place a second nick at the point so measured off. Then turn the flywheel until the index points to the dead center mark D1 (see Fig. 1) of the particular cylinder being dealt with, when the piston in this cylinder is at the top of the compression stroke. Next place the spoke through the compression cock of the cylinder, and turn the flywheel backward until the higher or firing nick on the spoke is just level with the top of the compression cock, and mark the flywheel, unless this has already been done, at the spot F1, to which the index then points. This will permanently locate the "lead" on the flywheel corresponding to the piston "lead" as marked on the spoke.

Having thus found the correct position, the operator should turn the starting handle until the tappet rod B (Fig. 5) is at the highest point, and should then slack the striker G on the

tapered part of the rocking shaft D, so that each is free to move independently of the other. The spring should be removed, and, holding the end of the contact lever shaft D, it should be turned to the left until the internal arm E is felt to be making firm contact with the igniter M. The striker G, on which the interrupter catch C acts, should then be pushed home on the rocking shaft D, without altering the ends vertically, and secured by the lock nut.

The critical part of the adjustment has now to follow. It consists of regulating the height of the interrupter catch C on the tappet rod so that when the tappet rod is at its highest point C will not be in contact with the end of the striker G. This means that the end of E will then, under the action of the tension spring, be in firm contact with M. The space between C and the end of the striker should be just sufficient to insure that they come into contact at the very moment that the index on the dashboard points to F1 on the flywheel. In other words, that the break between E and M takes place when the piston is within 1-64 inch of the top of the compression stroke, or, in other engines, at the distance recommended by the manufacturers.

This adjustment is a delicate one, and when necessary to effect may take some little time. The simplest way is to place a piece of very thin paper between C and the striker. Then turn the flywheel until the index (see Fig. 1) points to the letter on same referring to the particular cylinder being dealt with. At this stage the paper should be just held between the two surfaces against a gentle pull, and no more. In other words, the break between E and M is just about to commence.

The pressure should not be sufficient to depress the striker against the action of the spring, even to the slightest extent. The lock nut should then be screwed home. Should the threads fit loosely it may be necessary to slack back C about one-quarter turn, as the locking down of the lock nut may depress it on the rod too far. The same operation should be followed for the other cylinder. If the necessary delicacy and care has been observed in marking the flywheel and carry-

ing out these instructions, both cylinders will then be exactly similarly timed.

It must be borne in mind, however, that it is not sufficient, to insure the best results, that the break in the cylinder occurs at the correct moment. The amount of break is also a factor in the proper running of the engine. If the space between the interrupter catch and the striker at the highest point of the tappet rod is too great the break in the cylinder may be infinitesimal. If, on the other hand, the space is very small, the break will be too great, leading to excessive hammering between the contact lever and plug, and indifferent sparking, while in extreme cases the contact lever may even strike the cylinder. The movement of the striker should be only just appreciable when the engine is running.

The timing of a four-cylinder car should be effected on the same lines with the aid of Fig. 1.

It is necessary to remember always that the magneto gives the highest voltage of current when the edge of the rotating armature is just leaving the edge of the magneto field piece, and this should be the position when the contact is broken inside the cylinder. The only adjustment for this is to alter the relative position of the armature sleeve shaft of the magneto with the engine or valve shaft. This is hardly an adjustment which the amateur mechanic can satisfactorily carry out.

In some types of low tension contact breakers or igniters the contact arm is drawn away from the insulated igniter plug by the sudden releasing of a spring due to the tappet dropping into a recess in the cam. In such cases it is necessary to see that the contact arm or its equivalent is free and is held up to the insulated plug just before the time of breaking contact, and the amount of slackness which is allowed between the descending tappet and the arm should be the same in all cylinders.

Most cars are supplied with an index on the dashboard and the proper marks on the flywheel. It must be borne in mind, however, that any wear in the connecting rod brasses will alter the relative position of the flywheel to the index when

the timing is best tested, and consequently it will be impossible to make the adjustment with the delicacy that is required until the bearings have been adjusted. It must also be remembered that in different sized engines, or engines running at different speeds, the position of the piston, when (to give the best results) the spark should occur, varies considerably.

We would, therefore, impress the following points on the owner:

1. When the car is received new from the makers with the flywheel marked, he should place the flywheel so that the index points to the dead center mark D1 (Fig. 1), and then putting a spoke through the compression cock, nick it as already described. He should next turn the flywheel until the index points to the ignition mark F1, and should again nick the spoke. He has now got the exact position of the piston at which ignition should take place, and should keep the spoke for future reference, so that when adjusting the timing he can check the flywheel marks by means of the piston position, as shown by the spoke. A separate spoke should be kept for each cylinder, as before explained. If he finds, after use, that they do not agree, he may conclude that the connecting rod brasses are worn or need adjustment, and should have them seen to at once.

2. If on so testing, in the first instance, he finds that the piston positions in the respective cylinders do not agree, he may conclude that they are timed wrongly in respect to each other. He should then find out from the makers of the car the exact correct distance between the firing point and dead center, in millimeters or fractions of an inch, and, having marked a spoke accordingly, should alter the flywheel markings to correspond. Of course if, when in the first instance the dead center point is being marked on the spoke it does not correspond with the index mark on the flywheel, it can at once be concluded that the flywheel markings are wrong. When the index pointer is fixed on the dashboard it may happen that through collision or other cause the dash may be thrown over to one side. It is well, therefore, to measure from the inside

of either side of the chassis frame to the index pointer, marking its distance on either side. It can then be ascertained at any time if the index pointer has moved relatively to the engine crankshaft. Sometimes instead of altering all the marks on the flywheel an adjustment of the index laterally may put all right.

3. If a car has not been indexed and marked by the makers, and if the owner has omitted to do so when it was new, wear or looseness in the connecting rod bearings will upset his calculations. He should therefore first examine his connecting rod bearings to see if they are correct. If they are not, he should have them put right. He should then write to the makers for the correct firing position of the piston in the cylinder, and having himself taken the dead center position on the spoke, should carefully measure off the distance in fractions of an inch or millimeters (25 mm. equal 1 inch) as given him by the makers. The spoke having been correctly marked, he can now fix an index pointer on the dashboard, and mark the flywheel accordingly for timing purposes.

The igniter plug and the end of the striker arm get worn in process of time by the constant hammering, so that good contact is not made. They should be filed smooth, and then the timing readjusted. When either the igniter or striker, or both, get excessively worn they should be replaced.

The method of actuating the striker varies in different cars, and the fullest details should be procured on purchasing, together with particulars as to the method of adjustment. The principle, however, is the same in all.

The F. I. A. T. or Fiat is an example of a good system of low tension magneto ignition. It is described and illustrated under Ignition. In this the end of the tappet rod acts directly on the striker, and the adjustment of the latter on the rocking shaft is much the same as in the case of the Peugeot, described above. The contact arm, however, bears against the center stem of the igniter instead of the end, and this stem can be revolved when one portion gets worn and upsets the timing.

The High Tension Magneto System.

The high-tension magneto is the system of ignition now most largely adopted.

There are several different types of high tension magneto machines in use. Some of these are arranged to give a high tension current without the use of an outside separate coil, while others generate a low tension current, which is then passed through a separate induction coil which induces a high tension current.

The Bosch or Simms high tension magneto, in which the induction of the high tension current is obtained direct in the winding of the armature, is so arranged that there is no necessity for any adjustment of the timing, which is fixed and cannot be deranged, both contact maker and distributer being operated from one disk on the single shaft. The moment when the advance and retard lever K (see Ignition, Fig. 19) is at its most advanced position and the contact points break contact, is the time at which the piston should be in the position which will give it the required "lead," as explained earlier.

The machine itself consists of a magneto somewhat similar to that used with the low tension system of ignition, but in the low tension magneto there is only one winding on the armature (a low tension), whereas in the case of the high tension there are two windings. One of these (the low tension) consists of a few turns of thick wire, and the other (the high tension) a large number of turns of very fine wire. The current generated in the low tension winding induces a high tension current in the high tension winding; in fact, the armature may be considered a rotating induction coil. In some of the machines the armature does not rotate, but a rotating shield is used, as in some of the low tension machines. If a rotating shield is used, the machine (in the case of a four-cylinder engine) is run at camshaft speed, but if the armature rotates, it is run at the same speed as the engine.

The other essential parts of the machine are the low tension contact breaker, which is arranged to break contact just as the

armature has passed the maximum position, and the high tension distributer which distributes the high tension current to the respective spark plugs in proper rotation.

In the case of the rotating armature type of machine the distributer is mounted on the magneto and driven by a gear wheel keyed on the same shaft as the armature. It is obvious that, these gears being properly meshed, the correct timing of the distributer relative to the armature is insured. If for any purpose the magneto is dismantled it is necessary that the shaft carrying the armature and the shaft carrying the high tension distributer should be so assembled again that the distributer wiper makes contact just at the moment that the low tension contact breaker breaks contact.

In some cars the high tension distributer is fitted entirely independently of the magneto itself. When this is done the current is simply taken from the magneto to the distributer by means of a high tension cable.

The Eisemann magneto is an example of the machine generating a low tension current and passing it through a separate coil to induce a high tension current. This machine is fitted with contact breaker and distributer as described in the former type.

In the magneto system, whether high or low, the magneto machine is geared to the engine by some positive form of drive, generally by gear wheels, but sometimes by a chain. If the machine is fitted with fixed armature and rotating shield, it is driven at half the speed of the crankshaft. If, as is more often the case, the machine is fitted with rotating armature, it is then driven at the same speed as the crankshaft. If for any reason the magneto machine is disconnected from the engine, it will be necessary when replacing it to see that it is so timed that the contact breaker breaks contact when the piston of engine is in the correct position for firing, and also that the distributer brush of the high tension distributer is making contact with the terminal connected to the correct cylinder.

The best and obvious plan in dismantling the appliance is

to mark with a center punch the adjacent teeth of the gear wheels in mesh, and at the same time mark which contact of the high tension distributer is in contact with the brush. This is important as, the distributer being geared to run at half the speed of the armature shaft, it will be quite evident that the brush will have two different positions to correspond with the same position of the armature shaft. It sometimes happens, however, that the magneto has to be assembled when there are no marks on the wheels. To guide the assembler, the following method is then adopted:

Turn the engine until one of the pistons is in the determined firing position, as indicated by the index pointer against the flywheel, as already described. Then turn the magneto shaft into the position where the contact breaker has just broken contact. This is the time for firing. There will be a difficulty in holding the magneto armature in exactly this position owing to the pull of the permanent magnets on the armature. It can generally be wedged in some manner, and it should be so wedged that the armature cannot be moved and remains in the position we have indicated. With the engine, then, in the correct firing position and the magneto wedged in the contact-breaking position, the whole appliance should be moved sideways on its base into mesh with the wheel which drives it, and then firmly coupled up. In the case of the chain drive the chain can be simply slipped on.

Care of the Magneto.

Always see that the magneto is kept clean and free from superfluous oil. The machine itself should only require a few drops of oil every week.

See that the platinum contacts of contact breaker are kept clean. If from any cause they should get dirty and pitted, they should be carefully filed up and adjusted so as to give a break of somewhat less than half a millimeter.

Keep the high tension distributer clean and free from dust and oil. Do not put oil on the distributer.

If the magneto should fail to work, examine and see if the contact breaker is breaking contact properly. If it is not, the trouble may be due to the small rocking arm carrying contact not working freely on its pivot, or it may be due to one of the rollers which this lever strikes against not revolving freely. If both these are correct, the remedy is to readjust the contact screw. If the contact breaker is working correctly and still no current can be got from the machine, unscrew the high tension terminal at the opposite end of the armature, and see if the small carbon brush inside of same is making proper contact on the collector ring of armature. Also remove any carbon deposit resulting from the contact between the brush and collector ring.

Timing Gear and Half-Speed Shaft.—The timing gear of the engine consists of the system of shafts and cams which regulates the time at which the spark occurs in the cylinder, and also the correct opening and closing of the exhaust and inlet valves.

The timing gear and half-speed or two-to-one shaft are used to operate the valves and contact maker or breaker. To complete the Otto cycle the piston traverses the cylinder four times. During the first the inlet valve is open to admit the charge, during the next compression takes place, during the third the charge is ignited, while in the fourth the exhaust valve opens, and the cylinder is cleared of the spent gases. The consequence is that the valves and spark only require to be operated once in every four piston strokes or two revolutions of the engine crankshaft.

To attain this, a shaft, traveling at half the speed of the crankshaft, is provided, on which are mounted the cams operating the valves and the contact maker or breaker. To revolve this shaft at half the speed of the crankshaft two or more gear wheels are employed, one—that on the crankshaft—being half the diameter of the one on the cam shaft.

It is obvious that the same relative position of the cams and piston must always be maintained. The easiest method in

which to make any difference in this position is to loosen one gear wheel and turn it either to the left or right (if the valves do not open at the right time), thus engaging a different tooth in the other gear wheel, and giving the valve a "lead" or "lag" of its former position, according to the direction in which the gear wheel is turned.

Note that any alteration in the setting of the half-speed shaft on which the contact maker is fixed will affect the firing, and, should this have been correct before the change, it will have to be readjusted to suit the altered position of the shaft. See Timing, above.

PART V.

VALVES AND THEIR FUNCTIONS.

Valves—Valves are of many types, and are classified either from some peculiarity of shape, or from the functions they perform. The following are some of the valves used in motor-car mechanism and their chief uses:

Admission Valve.—The inlet valve. In modern practice the valve admitting the gas to the cylinder is of the same design as the exhaust valve, as illustrated further on. (See Inlet Valve.) The valve which allows the exhaust gases to pass to the gasolene tank in pressure fed systems is also a form of admission valve. (See Suction Valve.)

Air Valve.—A valve for admitting air to a carbureter or to a steam boiler, etc.

Annular Valve.—In some methods of construction one valve of the mushroom type is placed inside another. In this case the outside valve is an annular valve.

Atmospheric Valve.—See Suction Valve.

Back Pressure Valve.—The back pressure valve is of the nature of a check valve, and is used in feed pumps in steam motor cars to prevent the steam forcing the water back in the main water pipe.

Ball Valve.—A ball valve is one in which a ball sits down on a seating. The air or liquid in passing through the valve lifts the ball and flows around it, but on pressure being applied to return the liquid or gas, the ball drops down on its seat and prevents its passage. Ball valves, such as are used on domestic cisterns, where a hollow ball rises with the

water and closes the cock through the medium of a lever, are not used in motor-car work.

Blow-off Valve.—A blow-off valve is used in steam engines and is of the nature of a safety valve, allowing the pressure to be released when it reaches a certain predetermined amount. It is also part of a pressure feed system, and allows the release of the air pressure on the gasolene when it rises too high. The filling cap of the radiator is sometimes fitted with a release valve, which forms a blow-off valve, and allows of the escape of steam should the water boil.

Butterfly Valve.—See Throttle Valve.

Check Valve.—Any valve which allows a liquid to flow in one direction but not in the other may be rightly termed a check valve.

Clack Valve.—A clack valve is a non-return valve often used in pumps. It is a valve which sits down on a flat seat generally faced with leather, and is hinged at one side. It is very seldom used in motor-car work.

Conical Valve.—The ordinary valve used in motor car practice is a conical valve. (See Exhaust Valve.)

Delivery Valve.—A valve which allows a liquid or gas to flow through from the pump, such as in oil, air, or water pumps—the latter in the case of a steam car.

Exhaust Valve.—A valve which allows the exhaust gases to flow out from the cylinder on the exhaust stroke.

This type is the most important of all in internal combustion engine construction. The exhaust valve is set to open once for every two revolutions of the flywheel, so as to allow for the escape of the exploded charge.

The illustration shows how it is operated. A is the crank or engine shaft, on to which the pinion B is fixed, which meshes with the second pinion C, exactly double its size. C will therefore revolve once for every two revolutions of B. The shaft D, on which C is fixed, is consequently called the two-to-one or half-time shaft, and also operates the timing of the electric spark.

E is a cam which forms portion of the pinion C. F is the exhaust valve with its stem resting on J. J is the plunger working in a slide, which is actuated by the cam E. In the illustration it will be seen that the projecting part of the cam E is upward, and is lifting the plunger J, which in turn acts on the stem F, and lifts the exhaust valve off its seating, allowing the burnt charge to escape. When the cam

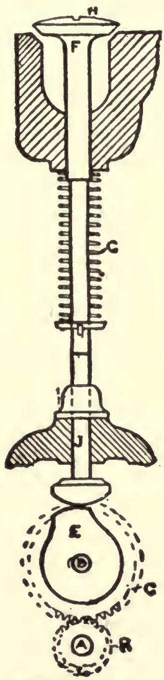


FIG. 1.—EXHAUST VALVE.

E moves a little further forward, the projecting part drops from under J, whereupon the spring G returns the valve to its seating, and the combustion chamber of the engine becomes gas-tight once more.

Practically the same construction is now almost universally used for inlet valves, except in some small motorcycle engines.

The illustrations (Figs. 2 and 3) show the two patterns of valve in use. That shown in Fig. 2 is by far the most common.

The exhaust valves of internal combustion engines are sometimes made with the head of a different metal to the stem, in order that the valve head may withstand the enormous heat of the exhaust gases better.

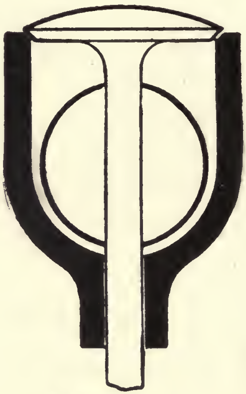


FIG. 2.

FIG. 3.

The head of the valve generally has a slot cut in it to receive a turnscrew for grinding-in purposes.

Feed Valve.—This term is generally used to refer to valves which allow the fuel to pass, such as the valve leading from the fuel pump in a steam car to feed the burner, or similarly to feed the boiler with water.

Flap Valve.—As the name implies, the flap valve comprises a "flap" of metal (sometimes leather-faced) hinged at one edge and bedding on a flat seat. This pattern of valve only permits a flow of water in one direction. Also called Leaf Valve.

Indiarubber Valve.—Indiarubber valves are not frequently met with in motor car practice, though they are found in motorcycle tires.

Inlet Valve.—Generally referring to the inlet valve to the cylinder. Most internal combustion engines are now built

with their inlet valves operated mechanically in the same manner as their exhaust valves, and where this method is adopted the inlet and exhaust valve are usually made interchangeable. This type is illustrated under "Exhaust Valve."

The size of the valves, of course, depends on both the size of the engine and the speed at which it is required to run. Many of the older types of engine had both inlet and exhaust valves too small, so that much power was lost both by throttling the inflow of gas, and by the back pressure caused in the exhaust. The higher the speed of the engine, however, the larger the valve should be, and the less the lift.

Mechanically Operated Valve.—The term used to differentiate between those valves which are opened by the mechanism of the engine, and those which are opened automatically by suction. In early engines, and also in a great many present motorcycle engines, the inlet valve opened automatically by the suction of the piston. It is now the general practice to open all valves at a stated time by means of cams.

Mushroom Valve.—The circular valves used in motor car practice are examples of the mushroom valve, the name being taken from the shape of the valve, which resembles somewhat that of a mushroom. Strictly speaking, a mushroom valve is one which has a head similar to that shown in the illustration, Fig. 3, under "Exhaust Valve."

Needle Valve.—A valve which is formed of a needle or slender spindle, its end being coned and falling or being screwed down on to a coned seating at the end of a small circular orifice. Needle valves are used in carbureters to automatically close the gasolene supply when the gasolene level in the float chamber is at the correct height. They are sometimes used to shut off gasolene, in which case they are screwed through the tank, and their conical ends sit down in a conical seating in the delivery pipe.

Piston Valve.—A valve which is arranged in the form of a cylinder having a piston sliding within it. The sliding of the

piston covers or partially covers, or opens or partially opens, an orifice in the side of the cylinder. Piston valves are used in connection with automatic carbureters to supply the extra air in various quantities according to the speed of the engine, the piston being operated through the medium of the suction above it or on a diaphragm to which it is attached. Piston valves are also used as throttles.

Pressure Valve.—A valve by means of which the pressure of the exhaust gas is used to feed gasolene to the carbureter, or oil to the sight feed lubricators. The pressure valve really contains two mushroom-headed valves, the one to retain the pressure, the other to act as a safety valve when the pressure

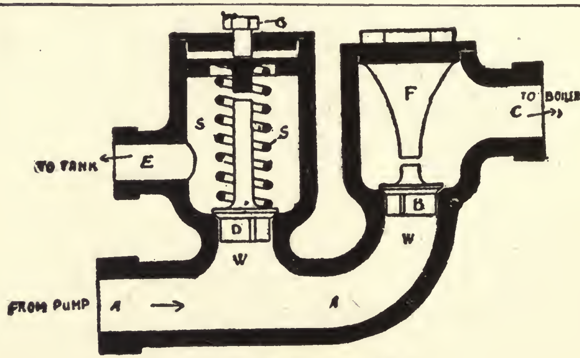


FIG. 4.—RELIEF VALVE.

rises above a certain point. The exhaust gas enters at a point below the head of the lower valve and raises it against the pressure of a spring, which tends to keep it closed and prevents the gas returning. The gas then enters a small chamber, from which a pipe leads to the reservoir. The top of this chamber is formed by the head of the second valve, which is kept closed by an adjustable spring. Should the pressure rise too high, this valve opens and allows sufficient gas to escape to reduce the pressure to the normal amount.

Relief Valve.—A relief valve is fitted to steam boilers and to oil and gasolene tanks under pressure in order to release the pressure when it rises above a predetermined point.

Our illustration shows one form of relief valve. The water enters from the pump at A and passes through the check valve B out to the boiler at C, the stop F preventing valve B from rising too high. This prevents the boiler pressure from acting against the pump. Should the pressure in the boiler rise too high for the pump to lift against, the relief or safety valve D rises against the pressure of the spring S regulated by the screw G, and the water flows back to the tank by the outlet or by-pass E. A steam safety valve is practically the same appliance without the addition of the check valve V or the boiler outlet W.

Rotary Valve.—This form of valve is used in connection with the steam distributers on a few steam cars. The valve is caused to revolve from the engine shaft, and acts by uncovering or cutting off passages by which the steam enters or leaves the engine. These valves are generally in the shape either of a long cone or a flat disk, and are pressed to their seats by the steam, so that in addition to the joint being kept tight, the wear is automatically taken up. In a few internal combustion engines where the cylinders revolve around the crankshaft, rotary valves become a necessity, but otherwise are seldom used in automobile work.

Safety Valve.—See Blow-off Valve.

Slide or Sliding Valve.—Sliding valves are not used in internal combustion engine practice to any extent, but they are often used in steam engine practice. They are a form of valve in which sliding plates cover or uncover ports which open onto a surface on which the plates slide as in the steam chest of a steam engine, the valve in this case being known as a slide valve.

Spring Valve.—Any valve which is controlled by a spring.

Suction Valve.—Any valve which opens by reason of a difference of pressure on either side of it is known as a suction valve. The automatically operated inlet valve of an internal combustion engine is a suction valve, and is opened by the difference in atmospheric pressure inside and outside the cylin-

der, due to the increased volume caused by the falling piston.

Throttle Valve.—The valve which throttles the area of the supply pipe from the carbureter to the engine in the case of an internal combustion engine, or from the boiler to the steam engine in the case of a steam engine.

In general practice, throttle valves are confined to two types: the butterfly valve and the plug throttle. With the first, a plate of metal, elliptic in shape, is attached to a spindle passing transversely through the valve. The edges of this plate are so beveled that when in its extreme position it completely closes the pipe. The maximum opening is obtained when the "butterfly" is parallel with the axis of the pipe. Adjustment between these two positions regulates the supply of gas to the engine. The illustration shows a butterfly valve in

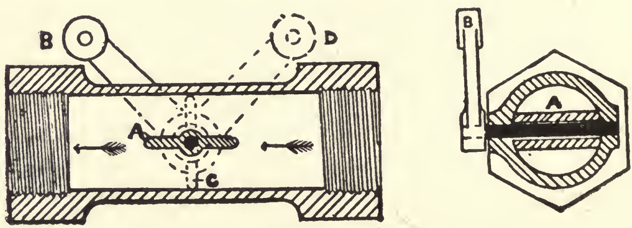


FIG. 5.—BUTTERFLY THROTTLE VALVE.

section. In the longitudinal section, the disk A is seen parallel to the center line of the bore of the valve. The spindle to which the disk is fixed is seen in the view of the end section, which also shows the actuating lever B. The dotted lines, as at C and D, show the valve closed, and the relative position of the actuating lever. This type of valve is largely used in connection with the governors of steam engines, being placed in the steam supply pipe.

With the second form the valve casing has a parallel bore in it, into which a cylindrical hollow plug fits and either turns or slides. This plug has apertures in it, and is operated by means of a lever or draw rod from the outside of the casing. The amount of opening can thus be regulated to a nicety by

turning or moving the plug to various positions. The throttle valve of a steam engine as used on steam cars is generally of the sliding type.

Tire Valve.—A non-return valve for allowing air to be pumped into a pneumatic tire and for preventing its return.

PART VI.

VALVE SETTING.

Valve Setting and Ignition Timing—Comparatively few motorists are at all sure of the methods to adopt when the necessity arises to reset the timing gear of their engine.

Such a knowledge might save considerable expense if at any time it became necessary to fit a new distribution pinion, a new contact cam, or another tappet on a low tension magneto make-and-break. But not only in a pecuniary sense is an understanding to be desired, but on the point of convenience also, for, in the event of a commutator or magneto driving chain breaking or becoming detached on the road, hours might be saved, says Mr. Marcus W. Bourdon in an interesting article on the subject, if the driver or owner was able to correctly replace the old chain or fit a new one; especially so, if the work could be done without hesitation, by reason of a knowledge of the best method to adopt in the process.

Setting the Valves.

We will imagine that the engine we are dealing with has mechanically operated inlet valves, and that these are fitted on the opposite side of the cylinders to the exhaust. We will also imagine that the small timing—by some termed "distribution," by others "two-to-one"—pinion has become loose on the crankshaft, by reason of the cotter securing it having fallen out. Not only so, but the pinion has moved forward on the shaft, and is out of mesh with the two large wheels, one on each side of it, and neither these latter nor the small one have any mark on their "faces" as a guide to refitting.

We thus have a condition in which the whole of the timing of both inlet and exhaust valves is upset. We have not only to refit the cotter in the correct direction according to the corresponding taper in the shaft and pinion, but we have also to mesh the teeth of both large wheels with those of the small one in such a way as to cause the valves to open and close at the proper time.

In dealing with a multi-cylinder engine, it is only requisite for this purpose to consider one of the cylinders, for if the valves of that one are correctly timed, those of the remaining cylinders will necessarily be in order also. For the sake of convenience, we will deal with the front, or No. 1, cylinder.

Now, a mechanical inlet valve should commence to open immediately after the exhaust valve has taken a seating—that is, closed—and both these points should occur when the piston is exactly at the top of its stroke. Therefore, in order to obtain a basis upon which to work in timing the valves, we must first of all turn the engine by means of the starting handle until the piston of the front cylinder is at its highest point. This can be ascertained by either pushing a piece of wire through the compression cock at the top of the cylinder, or if a tap is not fitted, by removing one of the caps covering the valves, from either exhaust or inlet side, when the piston will be seen or its movement felt by means of the wire.

The piston being at the top of its stroke, we must now turn the large pinion which is attached to the inlet camshaft to the left, or contra clockwise, that is, in the reverse direction of rotation to that of the crankshaft, until the front inlet valve commences to lift, or rather only until a slight pressure is exerted by the cam upon the valve tappet base, which pressure can be felt in turning just prior to the actual beginning of the lift. In some engines a loose or intermediate pinion wheel is situated between those on the crank and camshafts, and in such a case the camshaft revolves in the same direction as the crankshaft when the engine is running, and should be so rotated when testing and timing.

The inlet valves are now set. The exhaust camshaft must

now be turned in the same direction as the inlet side, until the valve of the front cylinder has just closed, and then all that remains to be done is to slide the small pinion along the crankshaft and into mesh with the teeth of the two large wheels, but at the same time keeping the holes for the taper pin in a line with that through the shaft, and making sure that the large hole in the pinion is at the same side as the larger end of the hole in the crankshaft.

If all the foregoing instructions are correctly carried out, the small pinion will mesh with the larger ones without the necessity for their being moved either one way or the other, and when they are meshed it will be found that the holes for the cotter pin in the shaft and pinion are in line. Before turning the engine, care must be taken to refix the pin tightly by driving it in with the punch and hammer, not using such force with the latter, however, as would be likely to bend the end of the shaft.

If the small pinion is driven by the shaft by means of a feather key as well as a pin, or only by a key, for all practical purposes the same instructions apply.

In some engines the ignition apparatus, whether high or low tension magneto, battery and coil, or otherwise, is driven by a chain directly from the back end of the crankshaft (the two-to-one reduction being obtained by the relative sizes of the chain sprockets), and not from one or other of the camshafts. If this had been the case with the engine the valves of which are supposed to be retimed, the method should have been as follows: When turning the engine at the commencement of the work, the time of firing No. 1 cylinder should have been noticed, by (if no other means are available) running the spark plug and observing when the spark takes place. This will occur, if the ignition lever is placed at about one-third advance, almost at the moment the piston reaches the top of its stroke. Note the spark, stop turning, then carefully turn the engine one complete revolution from the point where the spark took place. This should bring the piston to the top again, or at most vary but a slight degree one way or the

other, and after correcting any such variation, it is with the piston at the top of the stroke that the preceding directions regarding the setting of inlet and exhaust valves must be followed throughout. That is to say, the inlet valve must commence to open when the engine crankshaft has completed one revolution after reaching the top of the firing stroke. If a low tension magneto is used, the cams for giving movement with the firing tappets will be fitted on the crankshaft of the inlet side, so that in setting the inlet valves the timing of the tappets will also be accomplished.

Timing the Ignition.

(1.) Low Tension Magneto.—Supposing the magneto has been entirely removed, or, if chain-driven, the chain has become detached either by accident or design, the firing can be timed by one cylinder only, as with valve setting, and the engine must be turned by hand until one of the tappets is about to break contact with its firing plug in the cylinder. This can be judged by the external movements, for, bearing in mind that the tappet is normally out of contact with its firing plug, it will be noticed that in turning the engine contact is made and then rapidly broken; the rods giving this movement may either lift the tappets up and then pull them down, or vice versa, or, again, in some engines a rotary movement of the rods causes the tappets to make and break. Just as contact is about to be broken, cease turning the engine, and leave it at that. Then place the magneto on its bed, and, without bolting it down or allowing the teeth of the driving wheels to mesh, turn the armature by hand by means of the pinion wheel attached to it, in the direction in which it usually rotates, and in doing so it will be noticed that at certain points in each revolution a resistance to rotation occurs, followed by a tendency for the armature to spring forward in the same direction. Steady the hand by resting it on some fixed part, and slowly turn the armature until the resistance is overcome at one of the points, and the tendency to spring forward is felt. Then hold it securely in that position, mesh the pinions,

and temporarily bolt down the machine to the frame. If the engine does not then start as readily as usual, unbolt the machine and mesh the pinions at a point one tooth either backward or forward, experimenting as to ease of starting after each alteration. In the case of a chain-driven magneto with the chain detached, turn the armature slowly until the same point is reached, and then, if the chain sprocket cannot be held while another person fits the chain, wedge or secure it in some way with wire or string, but be careful that the armature does not move much in either direction during the fitting of the chain.

(2.) High Tension Magneto.—(a) The Eisemann Magneto. First of all set the ignition timing lever in such a position as will cause the spark to have about one-third of its advance, then turn the engine by hand until the piston of the front cylinder has reached the top of its stroke. This must be ascertained by means of a piece of wire applied through the compression cock, or the hole in the top of the cylinder where the valve cap is fitted. If it is noticed that the exhaust valve has just closed, or the inlet valve is just opening, one more complete revolution must be given to the engine crankshaft, and the position of the piston verified, for it must be exactly at the top. Remove the spark plug from the front cylinder, and rest it, with wire attached, on the top of the engine, or on a convenient spot where it has contact at the screwed end with ground. Now, by means of the chain wheel rotate the armature as sharply as possible half a turn at a time in the direction it usually revolves until a spark is seen at the plug; but immediately this is noticed, cease rotating the armature, and turn it slowly in the reverse direction until the platinum points on the low tension contact breaker are separated. This should first bring the machine to a point where it is in position for firing No. 1 cylinder, and the chain may therefore be refitted on the sprockets, care being taken not to alter the position of the one on the magneto. If the pawls on the high tension distributer are numbered 1, 2, 3, and 4, to correspond with similar numbers on the cylinders, merely turn the armature until

pawl No. 1 is in contact with the brass segment, and then move the armature again in one direction or the other until the platinum contacts are separate, as before. However, be sure that the piston is at the top of its stroke, and that the ignition lever is not advanced more than one-third of its movement.

(b) The Bosch Magneto.—The Bosch high tension magneto, as now made, varies considerably as compared with the Eisemann, in that it has no separate induction coil; in fact, unless the windings of the fixed armature can be so called, it has no induction coil at all. When retiming the ignition of an engine fitted with this type of magneto, it must be borne in mind that the machine gives four sparks in each revolution of the rotating sleeve—when fitted to a four-cylinder engine—as against two in the more ordinary type of magneto with a revolving armature. For the purpose of considering the matter of retiming this machine, we will suppose that it is driven by a chain, and that the chain is detached or broken.

When the Magneto is Chain Driven.

At the chain wheel end of the machine will be seen a solitary milled-edge screw, which holds in position the condenser and its casing. Remove this screw, and carefully draw away the condenser, and when this has been done the segments which form the revolving sleeve will be in view. Turn this sleeve by means of the chain wheel until a notch in the surface of one of these segments is seen. (This notch indicates the position of the revolving segment of the high tension distributer, and this latter, being situated at the opposite end of the machine, is so placed that it cannot be seen unless a number of parts are removed; and for this reason the makers provide the notch as a guide.) Now, allow the sleeve to be drawn back by magnetic force, or turn it by hand, until the notch is in line with one of the top high tension terminals, which are set at 90° from each other round the distributer. That is to say, set it in line with the terminal, which, when looking at the machine from the distributer end, is at the left-hand top

corner, and note that this terminal is in connection with the high tension wire, which is fitted the second from the left on the quadruple plug. Follow this wire along to the engine, and observe to which cylinder it leads. Then turn the engine by the starting handle until the piston of that cylinder is in a position for firing with a retarded spark, that is, about one inch down on the firing stroke; return to the magneto machine, set the timing lever in its retarded position, and rotate the sleeve very slightly—a movement of a quarter of an inch or so should suffice—by means of the chain wheel until the platinum points of the low tension contact breaker are in the act of separating. Hold the sleeve firmly in this position, and fit the chain on its wheel while they are so situated. Then slide the condenser back into place, and secure it with the milled-edge screw. If the foregoing directions are carefully followed out, the timing will then be in order.

Retiming with a Separate Distributer.

When retiming a high tension magneto the distributer of which is separate from the machine and driven by another shaft whose timing will therefore be unaffected, it is only necessary to see that the low tension contacts are in the act of separating, the piston of any one of the cylinders being at the top of the firing stroke and the ignition advanced about one-third, and then to fit the chain or mesh the pinions at that point.

High Tension Battery and Coil Ignition.

In refitting the driving chain, or meshing the pinion wheels, of a commutator with wipe contact in conjunction with a trembler coil, set the ignition lever advanced about one-third of its movement, and with the piston of No. 1 cylinder at the top of its firing stroke, namely, one complete revolution after the exhaust valve has closed, turn the commutator by hand until the trembler on the coil corresponding to the same cylinder gives forth its "buzz," and then fit the chain, or mesh the wheels in that position.

When the high tension distributer is fitted with only one coil, watch the former while turning the commutator by hand —with the ignition lever and piston arranged as above—and when the revolving "lead," or segment, is opposite No. 1 "collector," or high tension terminal, secure the driving mechanism, either chain or pinion wheels, at that point.

With a make-and-break contact and non-trembling coil, follow the same directions as those in reference to a "wipe," except that instead of turning the commutator until the trembler works, do so until No. 1 blade makes contact with the platinum-tipped screw.

In fitting a new wipe contact disk to the half-time shaft, it must not be taken for granted that the grub screw (or the cotter pin, if one is used to secure the disk) can be fitted into the same hole in the shaft as the old one. To obtain the correct position, or to verify the position, of the old hole, the piston of No. 1 cylinder should be at the top of the firing stroke as usual, and the ignition lever set at one-third advance. Then turn the disk on its shaft—in the direction in which it should rotate when the engine is running, and with the grub screw removed—until the blade or roller is in the center of its contact with the brass segment. With a long pin, or sharp-pointed tool, scratch the shaft through the screw hole, remove the disk and at the point where the scratches appear drill a hole to a depth of about one-eighth of an inch with a drill of the same size as the screw. Then refit the disk, tightening the screw into the hole just drilled.

Various Notes on Retiming.

When meshing the pinion wheels of an exhaust camshaft, the chief aim should be to so arrange that the valve closes at the instant the piston reaches the top of its upward movement after the firing stroke. Do not consider so much the point at which it opens; that at which it closes is of far greater importance, especially in engines fitted with mechanical inlet valves. Explosions in the carbureter, apart from loss of power, are likely to occur if both valves are momentarily open at the same time.

Synchronizing the Ignition Points.

If at any time it should become necessary to fit a complete new tappet, or maybe only the rocker arm, as used in conjunction with a low tension magneto, great care should be taken to adjust the movement of the lifting rod and the external arm on the tappet spindle in such a way as to cause contact with the firing plugs to be broken at the same point of the movement of the pistons in all of the cylinders. Failure to synchronize the movements would result in premature or late firing in one or more cylinders, causing a "knock," or in the latter case loss of power.

After Fitting New Parts.

It may be thought advisable at some time or other to fit a complete set of new tappets. In this case, supposing the period in the movement of the piston when the "break" occurred with the old one has not been noted before removing them, perhaps the best results are obtained, and that without backfires in starting, by so setting the new tappets that contact is broken when the piston is about a quarter of an inch from the top of its movement on the compression stroke. This, however, is with an engine with a fixed time of ignition; where an "advance" movement is provided the operator should retard fully and set the "break" to occur at the top of the firing stroke, not a quarter of an inch or so down this stroke, as with battery ignition with the lever fully retarded.

In the case of a high tension magneto where neither the low tension contacts nor the high tension distributer can conveniently be seen, and it is desired to refit the timing wheels, find approximately by sharp half-turns of the armature the point at which the spark takes place in the cylinder which has its piston at the top of the firing stroke, and then, by a rocking movement of the armature, set the timing, as described in the case of low tension magneto, by the resistance and "pull" to rotation which is felt. This, however, is not a certain method with high tension magneto, but it is near enough to merely

necessitate an alteration, if any at all, of but one tooth of the driving pinion or chain sprocket one way or the other—advanced or retarded.

Retiming with a Separate Distributer.

When retiming a high tension magneto, the distributer of which is separate from the machine and driven by another shaft whose timing will therefore be unaffected, it is only necessary to see that the low tension contacts are in the act of separating, the piston of any one of the cylinders being at the top of the firing stroke and the ignition advanced about one-third, and then to fit the chain or mesh the pinions at that point.

Care of Low Tension Magnetos.

Magnetos, wherever placed, should be carefully protected against oil and dust. Water does not affect the current-producing qualities of a magneto, except that it may cause a short circuit in some place or other, and therefore for this reason, and for the still more important one that rust destroys the connections, magnetos should be protected by a water-tight covering. Oil or gasolene deteriorates, softens, and ultimately dissolves the insulating material, besides serving to collect dust.

Care should be taken to lubricate the various magneto bearings. If force feed grease lubricators are not fitted, the oil lubricators should not be overfilled, and should be closed after oiling.

Such is the general attention which should be given to magnetos. The advice given with regard to fixity of terminals, carriage of wires, and plugs in the case of battery ignition, applies equally to magneto installations.

So long as the armature is not removed from its position between the pole pieces of the magnets, the latter will not lose any of their magnetism, but if the magneto is at any time dismounted and the armature removed for any purpose, the magnets should not be left a moment without protection. A piece of soft iron should at once be placed across the poles after the

manner of those attached to the little magnets sold as toys for children.

The windings on the armature may not be expected to break, but it is not difficult to test for a fracture of this description.

A short circuit in the wiring from magneto to plug is always easy of discovery, because of the very short length of wire.

A magneto should never be dismounted without marking it and its connection to the gear drive, so that it can be replaced exactly as before. The engine should be stopped with the piston in a known position. Expose the armature and carefully mark its position at the same time.

When a magneto is set to fire one cylinder, it is set for two or four, as the case may be.

Let us presume that a low tension magneto has been dismounted, and it is desired to replace it in its proper firing position:

1. Expose the armature by removing the plate covering it.

2. Turn the engine until one of the ignition tappets is about to break contact.

3. Put the ignition lever as far forward as it will go, when the armature should be as nearly as possible vertical—that is, with the current flowing at its maximum. We say as nearly as possible vertical, because in practice it is found best to give the armature web a slight inclination to the left, or backward in the sense of its rotation.

4. The magneto is properly adjusted if, with the ignition two-thirds retarded, the motor starts without backfiring.

One piece of advice must not be omitted: Never take a magneto to pieces. There is nothing in its interior to adjust, and you may quite upset its economy if you meddle with it.

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